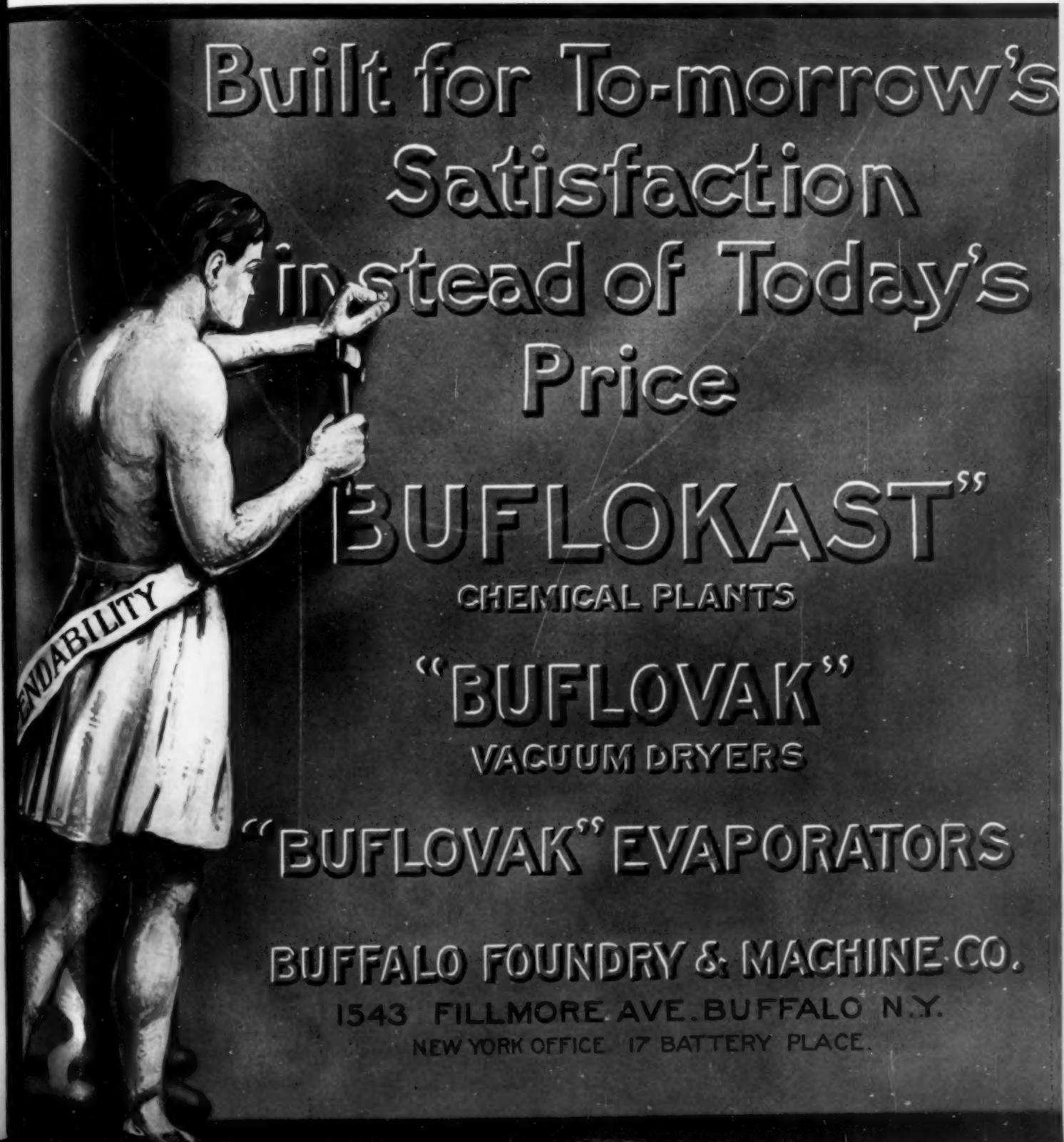
Reporting Spring Meeting of American Chemical Society

Metallurgical & Chemical Engineering

New York, May 1, 1917 McGraw-Hill Publishing Co., Inc. Vol. XVI, No. 9. 25c a copy



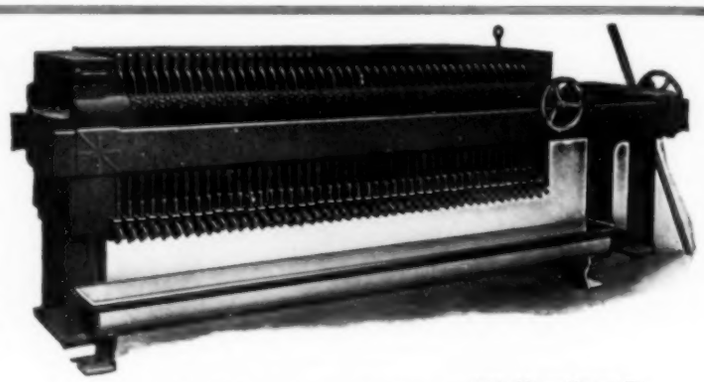
For Big Production and Low Operating Cost

SHRIVER FILTER PRESSES

They increase output and effect marked savings in filter cloth replacements and the recovery of values. Little attendance and less wash water adds to their economy.

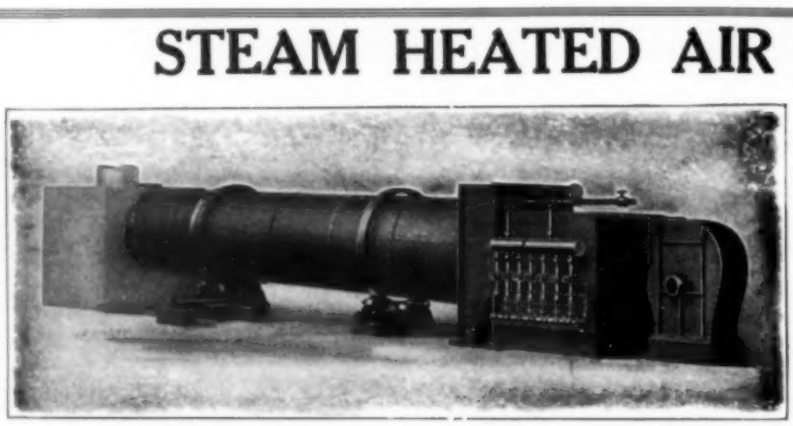
Have wide joint surfaces. Accurate finishing of plates and frames, coupled with an efficient tightening device, prevents leakage.

Presses for all industrial filtration. Small presses for laboratory work.



T. Shriver & Co. 808 Hamilton St. Harrison, N. J.

STEAM HEATED AIR DRYERS



for Drying Borax, Salts and other Chemicals.

Have equipped largest chemical plants in the world.

Also Direct Heat Dryers for By-Products.

American Process Co.
68 William St., New York

WHEN IN THE MARKET

Don't Forget that We Supply the Following Metals and Alloys

Ferro-Titanium, 25% Ti	Manganese, Pure
Chromium, 98-99% Cr	Manganese-Copper, 30/70%
Ferro-Chromium, 60% Cr	Manganese-Titanium, 30% Ti
Ferro-Vanadium, 40% Va	Manganese-Aluminum, 25% Mn
Ferro-Molybdenum, 80% Mo	Phosphor-Copper, 15% Phos
Cobalt, 97%	Silicon-Copper, 10% Si
Tungsten, 95%	Phosphor-Tin, 5% Phos
Ferro-Tungsten, 70%	Nickel-Copper, 50/50%

We are also in a position to quote on 50% Electro Furnace Ferro-Silicon manufactured by the Keokuk Electro Metals Company, of Keokuk, Iowa. This plant is now turning out a very high grade alloy, and, being centrally located, offers superior shipping facilities and freight rates. We represent this Company as exclusive selling agents.

Foundries making Brass, Bronze, German Silver, Nickel, Aluminum or composition castings should be sure to investigate our Pure Manganese and Manganese Alloys.

Ask for our pamphlet No. 2041.

GOLDSCHMIDT THERMIT COMPANY

THE EQUITABLE BUILDING, 120 BROADWAY, NEW YORK

329-333 Folsom St., San Francisco 7300 So. Chicago Ave., Chicago 103 Richmond St., W., Toronto, Ont.

Metallurgical and Chemical Engineering

A Consolidation of
ELECTROCHEMICAL AND METALLURGICAL INDUSTRY and IRON AND STEEL MAGAZINE

Vol. XVI NEW YORK, May 1, 1917 No. 9

PUBLISHED SEMI-MONTHLY ON THE FIRST AND FIFTEENTH OF EACH MONTH BY THE

McGRAW-HILL PUBLISHING COMPANY, INC.

JAMES H. McGRAW, President.
J. H. McGRAW, JR., Secretary. ARTHUR J. BALDWIN, Treasurer

239 West 39th St., New York.

TELEPHONE, 4700 BRYANT. CABLE ADDRESS, METCHEM, NEW YORK
ROCKY MOUNTAIN OFFICE.....401 Boston Bldg., Denver, Col.
PACIFIC COAST OFFICE.....Rialto Bldg., San Francisco, Cal.
CHICAGO OFFICE.....Old Colony Building
CLEVELAND OFFICE.....Leader-News Building
PHILADELPHIA OFFICE.....Real Estate Trust Building
LONDON OFFICE.....Hastings House, Norfolk St., Strand

E. F. ROEBER, PH.D., Editor.
S. FISCHER, PH.D., Western Editor.

J. MALCOLM MUIR, Manager.

Yearly subscription price for United States, Mexico and United States dependencies, $3.00; all other countries, $4.00.
Single Copy 25 Cents

When change of address is ordered, the NEW and the OLD address must be given. Notice must be received at least 10 days before the change takes place. No back copies for more than three months.

Copyright, 1917, by the McGraw-Hill Publishing Company, Inc.

Entered as Second-Class Matter at the Post Office at New York, N. Y., under the Act of Congress, March 3, 1879.

Contents for May 1, 1917

EDITORIAL:
The Kansas City Meeting of the American Chemical Society 465
Mental Efficiency 466
British Steel Consolidation 466
The late Anton Eilers 467

READERS' VIEWS AND COMMENTS:
Power of Aluminium Production. By M. M. Haff and C. O. Mailloux 468
Printers' Errors. By Carl Hering 469
Evasion of Patent Suit Decisions. By Parker C. Choate. 469
Coming Meetings and Events 470
Program of Detroit Meeting of American Electrochemical Society 470
Award of John Fritz Medal to Henry Marion Howe 471
The Dyestuff Consolidation 471
Dedication of the Chemical Laboratory of the University of Cincinnati. By E. E. Thum 471
Metallurgy in the Southeast Missouri District 472
New York Section of Society of Chemical Industry 474
Progress in the American Dyestuff Industry 474
The Zinc Works Pottery. By Edward Mackay Johnson 475
The Relation of Research to Everyday Life. By Dr. J. B. Weems 478
Spring Meeting of American Chemical Society in Kansas City 481
Benzene, Toluene and Xylene from Petroleum. By Gustav Egloff 492
The Embrittling Action of Sodium Hydroxide on Mild Steel and Its Possible Relation to Seam Failures of Boiler Plate. By Paul D. Merica 496
Grain Size Determination and Standardization. By Zay Jeffries 503
The Japanese Chemical Industry. By Professor Dr. H. Nishida 505
Oxidation and Reduction in Physical Chemistry—Consistency of Terms and Conceptions. By Carl Hering 507
Manufacture of Pig Iron in the Electric Furnace at Domnarfvet, Sweden 509
Synthetic Rubber. By Andrew H. King 511
Effusion Method of Determining Gas Density. By Junius David Edwards 518
Recent Advancement in Leather Manufacture. By Allen Rogers 524
Nitrate Industry in Chile 525

SYNOPSIS OF RECENT METALLURGICAL AND CHEMICAL LITERATURE 528
RECENT METALLURGICAL AND CHEMICAL PATENTS 531
Electric Steel Progress in England 533
Palladium-Gold Crucibles as Platinum Substitute 533
Hydraulic Asbestos Press 533
An Automatic Pressure Regulator for Pulpwood Grinders 534
An Interesting Application of Portable Elevators 535
An Instrument for Indicating Jig Performances 535
Metallurgical Fellowship at University of Utah 536
Accurate Determination of the Critical Point During Annealing 536
PERSONAL 536
BOOK REVIEWS 537
CURRENT MARKET REPORTS—The Iron and Steel, Non-Ferrous and Chemical Markets 537
INDUSTRIAL-Financial, Construction and Operation and Manufacturers' Notes 541

The Kansas City Meeting of the American Chemical Society

The spring meeting of the American Chemical Society was characterized by the very sincerity and earnestness that was to be hoped for from the chemists of a nation at war. The arrangements had been well and intelligently made, and the program was faithfully carried out. The Council met for dinner on the evening of the first day as guests of the Kansas City Section, at the University Club, and convened at Hotel Muehlebach at 8.15, as appointed. The session lasted until after midnight, a great deal of business was transacted with neither undue haste on the one hand nor acrimonious dispute on the other, and the leading thought at all times was how the members of this great chemical body may best render service to the government and the country. President Stieglitz is entitled to the highest praise for the wisdom, large intelligence and patriotism of his leading.

The following resolutions were passed in council and confirmed at the general meeting on Wednesday morning:

"Resolved, That we reaffirm the tender to the President of the United States of the services of the members of our society in all fields in which we are qualified to act.

"Resolved, That the security and welfare of the country demand the organization of all men and facilities of the United States as to secure the greatest possible service and value from each. The progress of the war thus far principally teaches us that modern warfare makes extraordinary demands upon science, food supply and finance. For the protection and success of our men under arms we recommend the use in their respective fields of all trained chemists, physicists and medical men, including advanced students of these subjects. To this end, in collaboration with the United States Bureau of Mines, we are preparing a census of chemists. With no desire to avoid field service for men of training in the professions named, we urge that those of ability be held to the work they can best perform. Thus we may avoid unnecessary loss from lack of control of the tools and requirements of war.

"Resolved, That the attention of the National Council of Defense be called to the scarcity of platinum under existing conditions and to the great need of the metal, more particularly in the prosecution of the war. We hold that its use at this time in the production of articles of ornament is contrary to public welfare. Therefore we recommend that an appeal be made to the women of the United States to discourage the use of platinum in jewelry, and that all citizens be urged to avoid its use for jewelry, for photographic paper, and

for any other purpose whatever, save in scientific research and in making of articles for industrial needs."

The professional sessions are reported very fully elsewhere in this issue, with abstracts of papers and discussions. Many of the papers from the various fields of chemical research were of distinct interest, although no report of any very marked or revolutionary achievement in science was recorded. There was the usual smoker, at which the members of the local section and students from the universities of Kansas and Missouri made merry, but within reason and propriety. All of the entertainments were "dry." At the banquet the note of preparedness was again dominant in all of the speeches. The toastmaster was Ex-President Herty, who presided with skill and facility. President Stieglitz gave some interesting notes on the history of the war and on conditions to-day. Professor Burbank of the University of Kansas told how that institution was contributing to the solution of problems of the day, and Prof. E. W. Washburn of the University of Illinois outlined the errors that had been committed, from a chemical standpoint, in the early days of the war, and pointed out how to avoid them as well as some of our present weaknesses. Mr. Ellwood Hendrick spoke on the need of publicity in chemistry and how to bring it about. Mr. J. H. Atwood of the Kansas City bar, brought a measure of eloquence and wit as well as real fervor to the need of preparedness that all will remember. Colonel Kealy of Kansas City closed with an appeal for greater co-ordination, and told where revivals of energy and reorganization of methods are desired.

On the whole, it was a good, sincere and profitable meeting—profitable to chemists and also to the country at large.

Mental Efficiency

Verily this is the day of preaching efficiency. We must make efficient use of our raw materials, our intermediate materials, our finished products. A sermon on economy as a phase of national efficiency is scarcely ended before we have to be reminded that this economy means only that we should avoid waste, that we must not economize by curtailing any of our industrial activities. It is all true, no doubt, but while in multitude of counselors wisdom no doubt lies, from multitude of counsels there is likely to arise weariness of the flesh and of the mind.

There we have it. Whose mind is not wearied in these times? The man you chance to meet in a business deal remarks he will make a note—he "can't remember anything these days." What occurred a week ago seems like ancient history. This morning's newspaper is "a back number." Yet of all times this is the time when we should be mentally efficient, which means not to make a greater effort but to accomplish more with the same effort or a less effort. We get nowhere by trying to think more or remember more. We must adapt our processes of thought to new conditions and limitations.

The fact of our entering a state of war instantly substituted for the old motive forces of the mind an entirely new motive force, that of our joining in a collective effort to accomplish a result for the country. By that change the mind became in reality less efficient, for it was not ordered by training or habit to respond to the new motive force. Unknown to its possessor, the mind has tended to respond to excitement, that is, etymologically, "running out," not the physiological stimulation or the energizing as of an electromagnet. It is the excitement of forgetting things. Such excitement may win battles, by the soldiers forgetting the danger confronting them, but it is not the excitement that helps us think to better purpose. We must study our minds afresh, how they can be made to work best in the new circumstances, the new circumstances that surround the nation, and the peculiar set of circumstances with which the exigencies of the times surround each individual.

Successful men have already trained their minds to be efficient, or they would not have succeeded. What is to be recognized now is that the conditions have been changed and the mind requires a new training that it may do the best work of which it is capable under these new conditions.

British Steel Consolidation

Just as we are thinking of how nicely we are going to avoid the mistakes England made in getting into a state of war, and how differently our industries will be aligned after we have been through the stress, comes the news that the British iron and steel makers are considering an amalgamation. Whether it is a complete merging of ownership or merely a pooling of products that is contemplated is not clear, if indeed the plans have gone far enough to develop into a definite project of either sort. The English have practical examples of the two methods, of the German Verband on the one hand and the United States Steel Corporation on the other. Both have succeeded, but the mode has been different. The German syndicates have succeeded because the plan itself was an excellent one, given the German temperament as the soil in which to flourish. The United States Steel Corporation has succeeded, not by any means through the wisdom of the plan, but through the wisdom that has characterized the administration of the corporation. We strongly doubt whether syndicates like the German would thrive in the United States or a German Steel Corporation would succeed in that country. There are great differences in racial temperament.

A little reflection, however, will show that if the British make the choice whether they will follow the one mode or the other they have only made a beginning in their plans. The circumstances existing are so different from those of the struggling times of peace in which the German syndicates and the United States Steel Corporation were conceived that most of the path toward any kind of an amalgamation that can be consummated are almost altogether unexplored. A few of these differences may be pointed out. The British steel

works are now under strict government control. When the Steel Corporation was formed there was not even the Sherman law—it was only a statute. The Government had lost the Knight Sugar Trust case and had not won the Northern Securities case. The German syndicates disposed of surplus steel by paying bounties on exports. English manufacturers will be kept busy paying taxes to the government. There can be no place in their philosophy for a scheme to give non-producing countries steel cheapened by taxing the home market. The Government will do all the taxing there is room for. The United States Steel Corporation had to be underwritten. That the underwriting was an easy success does not detract from the fact that there was a large and necessary risk to be undertaken. The British iron and steel manufacturers were in comfortable circumstances before the war started, and have made so much money since that they can do their own underwriting.

With no thought of trying to anticipate the plans of our British cousins or of undertaking to give them advice, it does not seem unnatural to suppose that the Kartell system will not appeal as fitting the existing circumstances or those that may be imagined as following the end of the war. On the other hand, a complete merging, the sale of each property in exchange for undivided interest in the whole, would be a halfway measure if it were to embrace but one-half the productive capacity of the country, as is the case with the United States Steel Corporation, and it is admitted that things would have to be different in the United States for our Steel Corporation to be a 100 per cent instead of a 50 per cent interest, and everything to be comfortable for all parties interested.

The British Steel Corporation would have to be under strict Government control, as to the prices it would charge and the wages it would pay. Perhaps such an amalgamation would do its part in helping to solve the intricate problem of wages and working conditions that will confront British industries when the war ends. The British workmen who have stayed at home have given much and have acquired new ideas as to spending money, while the men who have gone to the colors will have passed through an inferno and will be entitled to the best that wise counsel can provide for them.

We have a steel industry of our own, and after the war it is going to face new conditions. Through no wisdom in its plan or constitution, but through wise management mainly and through the proverbial American luck in part, it has succeeded. It was not feeling very successful in 1914. The Steel Corporation has been a balance wheel, to the profit of the other half more than to itself. It is merely the record of easily accessible statistics that when selling prices were low the Steel Corporation's production has been a smaller percentage of the country's total output than when prices were high, and that when export prices were below the domestic prices the Steel Corporation's export greatly preponderated, while lately, when export prices have been the higher, the Steel Corporation's proportion of the exports has greatly decreased. The existing arrangement is not a good foundation for the pull-all-together that must come after the war. We are going to have our problems.

The Late Anton Eilers

Frederick Anton Eilers who died on April 21 at his home in Sea Cliff, L. I., at the age of seventy-eight years, was the great old man in the metallurgy of lead. Born in Nassau, Germany, in 1839, he received his professional education at the School of Mines of Clausthal and at the University of Göttingen and came to this country in 1859. After various positions as mining engineer (from 1869 to 1876 as Deputy U. S. Commissioner on mining statistics and assistant of Dr. R. W. Raymond) Anton Eilers became associated in 1876 with the late Gustav Billing in leasing the old Germania works at Salt Lake City. In 1879 the Billing & Eilers lead smelter was built in Leadville, Colo. In 1882 Anton Eilers organized the Colorado Smelting Company and built the smelter at Pueblo, Colo. In 1888 he organized the Montana Smelting Company and built a large plant at Great Falls, Mont. After the merger with an East Helena, Mont., smelter and the National Refinery of Chicago, the name was changed to the United Smelting & Refining Company in 1890. All these plants went into the American Smelting & Refining Company upon its organization in 1899, of which Eilers was a director and technical member of the executive committee until the end of 1909 when he retired from active business. But his active interest in the profession to which he had devoted his life remained undiminished in his later years.

Anton Eilers has been called the father of modern silver-lead smelting and as such he will live in the history of metallurgy. It was preeminently Anton Eilers who changed lead smelting from a rule-of-thumb affair to an exact science by working out the theory and practice of slag formation on an accurate chemical basis. By extending immensely the range of ores that could be smelted at a profit and by reducing simultaneously the loss of values in the slag, Anton Eilers was a great and true conservationist in times when the term "conservation of natural resources" had not yet been invented. He proved likewise a great mechanical engineer in furnace design and smelter construction, as was shown by his introduction into practice of the sectional water-jacket of cast iron with flaring lip and of the water-cooled tap jacket. In this uncommon combination of higest ability as a chemist and as a mechanical engineer he was the prototype of the modern chemical engineer many, many years before the name was coined. But perhaps most important of all was his work in training men. He was great at this job all through his life and the famous Pueblo smelter was a veritable metallurgical university with graduates such as Hahn, Sticht, Arthur Dwight, Karl Eilers, among many. Anton Eilers built firmly for the future. The man and his work will not be forgotten.

Readers' Views and Comments

Power for Aluminium Production

To the Editor of Metallurgical & Chemical Engineering

Sir:—I would be pleased to get an explanation of the apparent inequality or variableness in the table entitled "Production Capacity for Aluminium," in Dr. Mailloux's article on page 329 of the issue of March 15, 1917, of this journal.

Why should the production capacity be so widely variant when reduced to horsepower year per ton of aluminium as follows?

Country	Aggregate H.P.	Capacity in Tons per year	Horsepower per Ton Aluminium
France	140,000	19,000	7.26
United States	105,000	12,500	8.40
Canada	20,000	2,500	8.00
Switzerland	27,000	6,000	4.50
Germany	5,000	600	8.33
Austria	5,000	800	6.25
England	21,000	3,800	5.5
Norway	21,000	2,100	10.00
Italy	4,000	1,200	3.33

I will except Italy—I suggest their figures are overestimated.

It would seem to follow that the stated aggregate power has not the direct bearing on the production capacity that the table would have me infer. Is it possible that there would be a great difference in the methods of producing aluminium by electric power (assuming that the third column in Dr. Mailloux's table does represent electric power).

The U. S. A. is a fairly high-priced power country, and from these figures the deduction is that they use nearly double the amount of power per unit of aluminium produced as compared with Switzerland. Why?

M. M. HAFF.

Ottawa, Canada.

* * *

To the Editor of Metallurgical & Chemical Engineering

SIR:—Mr. M. M. Haff asks for the explanation of certain discrepancies in the figures deduced by him from the table of production-capacity for aluminium, contained in my article on Electrochemistry and Electrometallurgy in France, on page 329 of your issue of April 15.

It is said that comparisons are sometimes odious. It is well known that they are dangerous and misleading when not properly made. Indeed, they may not only become impossible, but they may even be useless or absurd. The comparisons suggested by the figures in the last column of the table accompanying Mr. Haff's letter seemingly belong in this category.

The figures given in the table of production-capacity for aluminium were not intended to serve any other purpose than that of furnishing general statistical information. Like all figures representing aggregates, they are liable to contain many approximations and not a few inconsistencies which have the effect of making comparisons and deductions from them unsafe and deceptive. In order to have any significance at all, the figures that Mr. Haff has tabulated would need to be prepared by reference to data of entirely different character and quality. The aggregate power-capacity of a plant is, as is well known, a somewhat illusive and uncertain quantity. The problem of estimating the aggregate power of plants for producing aluminium is not a simple one by any means.

In the first place, it would be impossible to find two plants for producing aluminium that are alike, even in the same country. Each plant has its own characteristics, which reflect the knowledge, experience and ideas of its designer, and embody his views in regard to the amount of reserve or margin in production-capacity, available power, etc., considered suitable for such a plant.

In the next place, the exact amount of power available is oftentimes dependent upon circumstances which are quite beyond the control of the designer. This is particularly true in the case of waterpower, where nature has, in most cases, arbitrarily fixed the total amount of power available, and has also introduced obstacles and difficulties to be overcome in developing this power, which impose limitations on the amount developed, and influence, more or less arbitrarily, the cost of development. In some cases, additional power is easily obtainable, and its cost is very low; in such cases it would be natural to make the reserve of power rather large. In other cases, the additional power may be wanting or limited, and it may also be very expensive; and, therefore, the margin of reserve power must, of necessity, be reduced. Some plants have more power than they need; others have not enough power.

It is also important to distinguish between total production-capacity and actual output. This difference would, of itself, introduce an important correction in Mr. Haff's figure for the HP. per ton, in the case of France. Although, as stated in the article, France had, previous to the war, a total production-capacity of 19,000 tons of aluminium per year, the actual aggregate output from all these plants has never attained that figure. The diagram of aluminium production in different countries given on the same page as the table of production-capacity for aluminium (p. 329), shows that the total production in 1912 (the last year for which statistics are available) was only 13,000 tons. As stated at the bottom of page 329 the French aluminium plants have had to divert a considerable portion of their capacity to other work, owing to the small domestic consumption of aluminium, amounting to only 3000 tons, and the difficulty of finding a foreign market for their output, in competition with the plants producing aluminium in foreign countries.

The figures representing the nominal HP. capacity available per ton of production-capacity in a plant will vary within wide limits for the different plants in any one country. In the absence of full detailed knowledge of the characteristics and peculiarities of every one of the plants, it is impossible to form conclusions as to whether the figure given for aggregate power is right or wrong. It would obviously be necessary to make a rather exhaustive examination and study of every aluminium plant in each country in order to obtain data that could serve as a basis for the figures given by Mr. Haff; and even if one had such accurate data it would still be necessary to state the highest and the lowest values, as well as the average value; and it would doubtless be found that there is considerable discrepancy between the extreme values in each country.

Even if it were possible to obtain the figures of comparison that Mr. Haff has in mind it is hard to see what value they would have. The fact is that the cost of production of aluminium bears little, if any, relation to

the power available. It is, however, directly related to and depends upon the cost of the electrical energy actually used per ton of aluminium produced. If a comparison could be made between the different aluminium producing plants, from the standpoint of the electrical energy actually used in HP.-years or KW.-years per ton of aluminium, it would probably show that the differences between the highest and lowest energy-consumptions are not very large. Even here, however, these differences could not be contrasted and compared without taking into consideration the characteristics of the method or process employed in making aluminium. It is well known, for instance, that the percentage of fluorides of various kinds contained in the bath has a considerable influence on the fusing temperature of the bath; and the melting point, in turn, influences the amount of current, consequently the amount of electrical energy, required to keep the bath fluid. So even in this case a comparison would have little meaning or utility in the absence of complete information in regard to the method or process employed.

In view of all these circumstances it is difficult to see that deductions such as contained in the last paragraph of Mr. Haff's letter are warranted or present any interest. They imply and would require information far more exhaustive and circumstantial than is available or procurable anywhere. The final question is thus seen to be useless. It is consequently unnecessary to consider further the great difficulty, in fact the impossibility, of answering it satisfactorily.

C. O. MAILLOUX.

New York City.

Printers' Errors

To the Editor of Metallurgical & Chemical Engineering

SIR:—In my article on Electrolytic Equivalents of Gases in your issue of April 1, near the top of page 383, the last line of the table should read 12,158 instead of 12.158, that is, it should be 1000 times as great, or else it should read in kilo-ampere-hours instead of ampere-hours.

On the fourth line, near the top of page 383, the word "valences" should be "bonds." The valences alone sometimes do not add up to zero unless multiplied by the number of atoms of an element in a compound, but the bonds always do.

CARL HERING.

Philadelphia, Pa.

Evasion of Patent Suit Decisions

To the Editor of Metallurgical & Chemical Engineering

Sir:—In a recent audience with the president of one of our largest metallurgical industrial corporations I was advised by him that any industry was glad to pay royalty to the inventor, but that when the royalty was demanded by capitalized interests industry sought to avoid recognition of royalty, because it was assumed that the inventor had received compensation, when capital took possession of the invention for exploitation purposes.

This thought struck me as the theoretical basis of corporation conscience relative to research. We see it falling short in practice, because the corporations themselves use every effort to obtain possession of common-commodity inventions on the plea that they desire to protect their practice, but in reality for the purpose of preventing the common-commodity use, dictating what the inventor may receive, and suppressing application to the detriment of the community.

After many experiences I am inclined to feel that the pure thought above expressed by a very able minded president of an industrial concern is merely an ideal that it is not possible to put into practice; first, because the inventor is unable to develop his metallurgical, and thus expensive research, unless he assigns to selfish industrial interests, and second, because the invention so assigned is fought as a business principle. It is extremely rare to find an inventor with adequate capital to demonstrate his invention; hence, if he refuses to assign, because by so doing he would defeat technical development and community advance, he is denied income, and there results the great loss to community.

Suggestions of union research under special royalty contracts to the subscribers to such union action are not considered.

Industry plainly proclaims: Assign to one of us or you can't have money for demonstration, and if you do assign to one of us all the rest will fight the patents, and you as inventor will get only a good salary until we think we can do without you.

The U. S. patent law is openly defied.

All this has happened to inventions recognized of radical and material value by industry. It is in no way imaginative, and it is entirely within my personal notice.

It seems to me that the position which part of the defendants take in the flotation litigation illustrates this practice, which I have described as existing previous to demonstration, where the inventor alone, with merely his mentality, seeks to get any individual recognition and administer his royalties and is refused such.

In a former article I have analyzed this case and given a remedy (see this journal, issue of March 1, 1917). The Minerals Separation, Ltd., came into possession of valuable patents that were at once seized upon as soon as demonstrated. The courts decide the patents are valid and all users must pay royalty, but many corporations refuse, and openly say they will avoid the details of the court decree by using more than 1 per cent of oil in the circuit.

They talk of a new process, yet perhaps there is no technical reason why more than 1 per cent of oil gives better results, but merely the commercial reason to avoid royalty payments to a capitalized patent interest that must be fought, right or wrong. It reminds one of the present European war, for which no real reason exists, while community interests are wrecked.

It does not appeal to me that the use of an amount of oil in excess of 1 per cent, that is an excess over that really needed to wet and float the mineral, can stand as anything else but an attempt at evasion of the patent and a means of prolonging the industrial war and obtaining a further Supreme Court decision, in the hope that the court may reverse itself, as proclaimed by A. B. C. in a former issue of this journal (February 1, 1917). So long as the excess of oil above that used in wetting and floating the minerals is caught and again used the evasion is clearly a commercial one to avoid royalty, and the use of the legalized patent exists, with infringement evident. Even if the excess of oil is not saved, entailing a commercial waste, the waste appears merely as an evasion of royalty.

In the trend towards socialism and better community protection, it would not appear that the Supreme Court will look upon the so-called new process, involving the use of more than one per cent of oil, with no technical advantage over 1 per cent or less, and obviously greater industrial costs and thus community waste, as anything else but an evasion of its decision and determination to make respected the patent laws of the United States, so long used as a football by industry.

How much better it would be if the idealistic theory of the industrial executive quoted were a fact and in-

dustry should recognize the inventor as an individual, or accept administration of his mentality through impartial boards of trustees and provide such trustees with adequate funds to demonstrate research.

The futile attempts for industry to conduct radical research with beneficial results, with few exceptions, must be very apparent to the impartial or analytical mind.

PARKER C. CHOATE.

Essex, Mass.

Coming Meetings and Events

American Electrochemical Society, spring meeting, Detroit, Mich., May 2-5, 1917.

Award of John Fritz Medal to H. M. Howe. United Engineering Building, New York, May 10, 8.30 p. m.

Technical Association of Pulp and Paper Industry, annual spring meeting, Neenah, Wis., May 24 and 25, 1917.

American Iron and Steel Institute, New York, May 25-26, 1917.

American Institute of Chemical Engineers, semi-annual meeting, Buffalo, June 20-22, 1917.

American Society for Testing Materials, Atlantic City, June 26-30, 1917.

Third National Exposition of Chemical Industries, Grand Central Palace, New York, week of Sept. 24, 1917.

American Institute of Metals and Foundrymen's Association, Boston, week of Sept. 24, 1917.

American Electrochemical Society, autumn meeting, Pittsburgh, Oct. 3-6, 1917.

American Institute of Mining Engineers, annual meeting, St. Louis, Oct. 8-13, 1917.

Program of Detroit Meeting of American Electrochemical Society

The headquarters and registration bureau for the spring meeting of the American Electrochemical Society, to be held in Detroit from Wednesday, May 2, to Saturday, May 5, will be at the Hotel Statler. Arrangements have been completed by local committees of which Edwin L. Crosby is general chairman.

All the sessions of Thursday, Friday and Saturday will be held in the Auditorium of the Detroit Board of Commerce Building, Lafayette Boulevard at Wayne Street.

Wednesday afternoon, May 2, visits are scheduled officially to the Dodge, Packard, Hudson and other automobile plants. Automobiles will leave Hotel Statler at 2.00 p. m. (All expecting to take this trip should notify Miss Edna J. Raybould, Secretary to the Committee on Arrangements, 18 Washington Boulevard, in advance and should designate, when registering, which route they wish to take.)

Wednesday evening, May 2, members and guests are invited to a "Get-together" subscription road-house dinner at "West Wood." The party will leave the Hotel Statler at 6.00 p. m.

Thursday evening, May 3, a smoker will be held at the Hotel Tuller, Roof Garden, at 8.00 p. m.

Friday afternoon, May 4, excursions will be made to electric steel plants, power houses and the Lake Shore Drive.

The annual business meeting will be held on Thursday morning (9.30 a. m.) in the Auditorium of the Detroit Board of Commerce Building, Lafayette Boulevard at Wayne Street. (Report of Board of Directors, announcement of annual election, vote on amendments to the Constitution, discussion of report proposed by Committee on Public Relations on "Water Power Legislation."

This will be followed by the Presidential Address of the retiring president, Mr. F. A. J. FITZGERALD.

The following papers will then be read and discussed:

J. A. MATHEWS: Comments on the Electrical Steel Industry.

R. F. FLINTERMAN: The Electric Furnace in the Steel Casting Plant.

J. L. DIXON: The Grönwall-Dixon Furnace.

The program of the afternoon session (2 p. m.) contains the following papers:

C. A. BUCK: Ten-ton Girod Furnace at Bethlehem Steel Co.

C. H. VOM BAUR: Rennerfelt Electric Furnace Operation.

A. A. MEYER: Restifying Action of the Arc in Electric Steel Furnaces.

R. G. WILLIAMS: Grinding Wheels.

LIGON JOHNSON: The History and Phases of the Smoke Problem.

W. W. STRONG: Theoretical Aspects of Electrical Precipitation.

In the session on Friday morning (9.30 a. m.), the following papers will be read and discussed:

W. R. MOTT: Chemistry of the Flaming Arc in Relation to Luminescence.

W. C. MOORE: The Vosmaer Phenomenon.

O. L. KOWALKE: Acid Corrosion Tests on Some Iron-Silicon Alloys.

E. A. RICHARDSON and L. T. RICHARDSON: Corrosion of Cast Iron and Its Bearing Upon the Electrical Theory of Corrosion.

C. F. HIRSHFELD: Some Low Temperature Electro-Thermic Processes.

W. C. BROOKS: Automobile Storage Batteries.

M. DEKAY THOMSON and L. R. BYRNE: The Current Efficiency in Charging Edison Storage Batteries.

W. L. BADGER: A Switchboard for Experimental Electric Furnace Work.

M. DEKAY THOMSON and T. C. ATCHISON: The Production and Properties of Magnetite Electrodes.

In the evening of Friday (8.30 p. m.) an address will be made by Mr. Alex. Dow, President of the Detroit Edison Company, on "Electrical Power from Coal." Ladies are cordially invited to attend.

For the concluding session on Saturday morning, (9.30), the following program has been arranged:

W. E. KOERNER: Electrolytic Behavior of Tungsten.

M. DEKAY THOMSON and O. L. MAHLMAN: The Electrolytic Pickling of Steel.

F. C. MATHERS and K. S. MEANS: Tests of Antimony Plating Baths.

F. C. MATHERS, K. S. MEANS and B. F. RICHARDS: Electro-Plating from Fluoride Baths Containing Addition Agents

F. C. MATHERS and L. G. BLUE: Addition Agents in the Deposition of Silver from Uncommon Salts.

F. C. MATHERS and A. B. LIBELE: Effect of Essential Oils as Addition Agents.

T. B. BRIGGS, H. L. PIERSON and H. S. BENNETT: Electrical Endosmos and Absorption.

O. P. WATTS and A. BRAUN: Deposition of Hydrogen in Cyanide Plating Solutions.

T. W. CASE: A Cuprous Oxide Photo-Chemical Cell.

The special program for the entertainment of ladies contains a Lake Shore drive for Thursday afternoon. (Tea at Belle Isle or Detroit Athletic Club.) A theater party for Thursday evening ("Winter Garden Show.") and for Friday afternoon a drive through Bloomfield Hills. (Tea at Bloomfield Hills Golf Club.)

Eastern Standard Time is used in Detroit, and is the

time indicated in this program. The railway time table indicate Central Time. Visitors are cautioned to take notice of this fact.

Arrangements have been made with the New York Central Railroad to operate one or more sleeping cars for the exclusive use of members attending the convention from New York City. Special fares will be allowed if the number is large enough. The train recommended is the "Wolverine" leaving Grand Central Terminal 5.00 p. m. Tuesday, May 1, and arriving at Detroit 7.10 the following morning.

Award of John Fritz Medal to Henry Marion Howe

The John Fritz Medal has been this year awarded to Dr. Henry Marion Howe for his investigation in metallurgy, and especially in the metallurgy of iron and steel.

The John Fritz Medal is awarded by the John Fritz Medal Board of Award, which body consists of four members from each of the national engineering societies, viz., the American Institute of Mining Engineers, the American Society of Civil Engineers, the American Society of Mechanical Engineers and the American Institute of Electrical Engineers. It represents the highest reward from the engineering profession for distinguished services.

The presentation ceremonies will take place on the evening of Thursday, May 10, at 8.30 o'clock, in the Auditorium of the United Engineering Building, 29 West Thirty-ninth Street, New York.

Addresses are expected from Dr. Rossiter W. Raymond, Dr. Ira N. Hollis, Judge Elbert H. Gary and Prof. Albert Sauveur. Ladies are specially invited.

The Dyestuff Consolidation

The announcement in our last issue of the merger of the Schoellkopf Aniline and Chemical Works of Buffalo, the W. Beckers Aniline and Chemical Works of Brooklyn, the Standard Aniline Products Company of New York, and the National Aniline and Chemical Company of New York is supplemented by later information which includes in the consolidation the Benzol Products Company of New York and the various processes and interests of the General Chemical Company, Barrett Company and Semet-Solvay Company.

Financial details of the organization of the new company, which will be known as the National Aniline and Chemical Company, Inc., are in the hands of Eugene Meyer & Co., bankers of 15 Wall Street. The capitalization of the new company has not yet been announced.

The new company will be in a splendid manufacturing position, as it will have the necessary crudes and intermediates produced in its own plants and will have a very large finished dye-making capacity. The following statement was issued to us by I. F. Stone, president of the old National Aniline and Chemical Company, the selling company for the Schoellkopf Aniline and Chemical Works.

"A company is being formed known as The National Aniline and Chemical Company, Inc., to take over the Schoellkopf Aniline and Chemical Works, with its line of dyestuffs; the W. Beckers Aniline and Chemical Works, with its line of dyestuffs, and the Benzol Products Company, producers of aniline oil and salts and also of certain of the coal tar intermediates—these three concerns in their entirety. It will also acquire certain minor interests and processes in coal tar intermediates already developed and developing of the General Chemical Company, the Semet-Solvay Company and The Barrett Company.

"This company will be in a position not only to make the intermediates and dyestuffs now being made by those concerns, but it hopes to be able ultimately to extend its field to other intermediates and other dyestuffs, as well as to pharmaceutical products and photographic chemicals and coal tar explosives.

"The busineses and processes of the various concerns thus taken over, each being engaged in a separate branch of the industry, fit into and supplement one another, and the new company thus formed will be a highly integrated concern, as are the large dyestuff companies of Germany, which prior to the war practically controlled the entire business of the world in dyestuffs, coal tar intermediates and the like.

"It is the hope of the parties interested that with a continuation of the friendly co-operation of the Government and of the consumers of dyes of the new company and others in the field will be able to meet on even terms after the war the competition of those foreign concerns that formerly controlled the business. The parties interested not only are endeavoring to retain for the United States as much as possible of the business which war conditions have enabled them to develop in a temporary way, and precariously, but also to supply the need of late so acutely felt in this country for a coal tar color and chemical industry highly developed in all its branches."

Dedication of the Chemical Laboratory of the University of Cincinnati

On Saturday, April 7, 1917, dedicatory exercises were held at the University of Cincinnati, formally opening the new chemical laboratory, which, however, has been occupied by the chemistry and metallurgical departments* since the opening of the current school year. The exercises were held in the auditorium of the University, following a public inspection of the new building and its equipment.

In a few words, Mr. Robert Hochstetter formally presented the keys of the building to the head of the chemistry department, Dr. Lauder William Jones. In reply, Dr. Jones sketched briefly the growth of chemistry at the University of Cincinnati since the early seventies under the leadership of Frank Wigglesworth Clarke, Thomas H. Norton and Thomas L. Evans, and accepted the trust left by these distinguished predecessors. As an ideal for the new laboratory he proposed that the value of pure science be continuously emphasized, especially in the teaching and investigation of the so-called applied chemistry, with the understanding that the union of the two is absolutely necessary for lasting progress in the arts.

Dr. John Uri Lloyd then made a few remarks on behalf of the American Chemical Society, in which he spoke of the work of the pioneer chemists of Cincinnati, and how the few survivors of that band were now having their hearts gladdened by this material evidence of the fulfillment of their hopes and expectations.

Dr. Charles E. Herty, past-president of the American Chemical Society, then presented an address on "The Swing of the Pendulum in Chemistry." Dr. Herty described the condition of our infant chemical industries in 1914, prior to the outbreak of the great war, and the hurrying and scurrying incident to shutting off the German chemical importations. An immediate effort was made to produce locally the enormous quantities of chemicals and dyes required by the United States, re-

*A full description of the courses in these departments was published in our issue of April 1, page 367.

sulting in a plant expansion valued at $200,000,000. Large drains upon the chemical faculties were made by the industries in order to manage this large increase in plant capacity—at the same time the importance of applied chemistry in our national life was influencing hundreds of young men to enter chemistry and chemical engineering. The result is now found to be laboratories overcrowded with students and undermanned with instructors.

For the good of the industry as well as of the University (for the industry will make small progress without a sound foundation built upon academic training), it is absolutely necessary that the pendulum now swing back to the University. It is necessary that boards of trustees and executive officials make a strenuous effort to counteract the attraction which the industry exerts upon their teachers by raising salaries, furnishing more laboratory assistants and new equipment to handle the larger number of students, and providing their faculties with materials and time for research in their chosen fields. Otherwise the continued exodus of chemists from teaching into practice will ultimately spell disaster for both.

At a banquet tendered by the Cincinnati Section of the American Chemical Society during the evening, Dr. Alfred Springer presided as toastmaster. He called attention to the present necessity for the chemist to help the farmer rather than the urbanite by devoting his efforts to the production of synthetic fertilizers by fixation processes, calling attention particularly to the work recently published by Bucher of Brown University.

President Charles W. Dabney, responding to "Chemistry in a University," pointed out the immense services rendered by the science of chemistry to human thought and life in general by establishing an absolute freedom in the right to experiment and think inductively in the search for truth, no matter where that search led or what idols it destroyed.

Prof. L. W. Jones described the transmutation of the "base" employee in a dirty hole who analyzed the pig iron to the "noble" investigator of the modern research laboratory.

Dr. Martin Fischer called attention to the ancient Chinese idea that the true value of human effort may be appraised thus: first, that of the scholar, who produces values out of nothing; second, of the farmer, who produces out of the earth; third, the artisan, who shapes cunning things from rough materials; and lowest, the merchant who, in his effort to buy cheap and sell dear, cheats both sides. Unfortunately, as measured by our present standard of monetary return, the value of these classes to our civilized world seems to be in the inverse proportion to that existing in olden times.

E. E. THUM.

Promotion of Research at Universities

The National Research Council established by the National Academy of Sciences at President Wilson's request to organize the scientific resources of this country in the interest of preparedness and to foster scientific and industrial research through co-operation, and by other means, has asked all the important universities, colleges and scientific schools to appoint committees consisting of members of their faculties and boards of trustees to consider and report on methods by which research can be best promoted within the institution. These have already been appointed at many institutions. The University of Pittsburgh has appointed Messrs. Bacon, Brashear, Griffin, Guthrie, Holland, Lincoln, Schlesinger and Thorpe, with Dr. George H. Clapp as chairman. The Masachusetts Institute of Technology has appointed Messrs. J. R. Freeman, F. R. Hart, A. D. Little, C. T. Main, G. E. Hale, W. R. Whitney and Jaspar Whiting of the alumni, and Professors Cross, Kennelly, Lewis, Lindgren, Noyes, Riley, Whipple and Wilson of the faculty. President Maclaurin is chairman of this committee.

Metallurgy in the Southeast Missouri District

If there is anyone who does not know yet that St. Louis is a mining and metallurgical center of greatest importance, and that, for instance, the southeast Missouri district, about 80 miles south of St. Louis, is the largest lead district in the world, he will learn all about it before the meeting of the American Institute of Mining Engineers, to be held next October in St. Louis, is over.

The members of the Institute living in the lower Mississippi Valley have already started in making preparations for the meeting and are extending a hearty and cordial invitation to their fellow members to meet with them in St. Louis. It will be a meeting of singular interest inasmuch as the district in question can show in active production almost all of the more useful metals and non-metals.

To the publicity committee of the Institute (Mr. J. D. Robertson, chairman) we are indebted for the following notes on the southeast Missouri lead district and for the photographs reproduced on the adjoining page.

During the St. Louis meeting a special trip will be made to the southeast Missouri district. This was already the largest lead district in the world before the European war, and now that the production of lead has greatly decreased abroad, and has correspondingly increased in the United States, this is one of the most interesting of all lead districts.

In 1913 the production of the world was 1,270,000 tons, the last world figures obtainable. In that same year the production of the United States was 412,000 tons, and of southeastern Missouri 133,000 tons. In 1916, the world's production having fallen off, the production of the United States was over 600,000 tons, and that of southeastern Missouri 184,000 tons (32 per cent).

In view of the great necessity for lead at present, and so far as we can foretell for the future the possibilities not only in this known district, but in contiguous areas, are not only interesting but decidedly important.

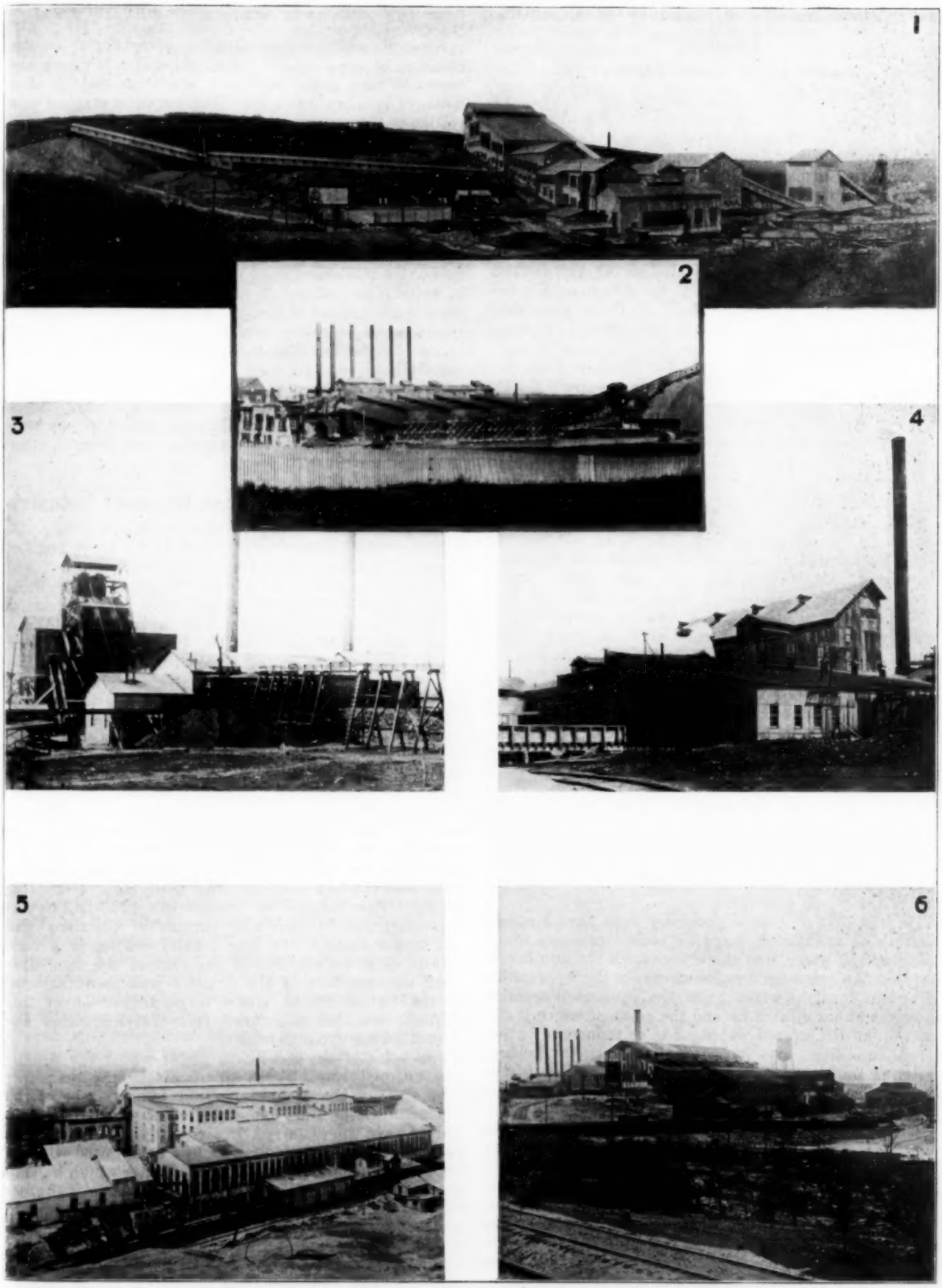
The ore occurs not in veins, but disseminated through a great bed of magnesian limestone, more than 400 ft. thick in places, and when mined only carries an average of about 3 per cent lead. It has taken nearly a generation to perfect the concentration plants, and the managers do not consider them perfect yet. Here this ore is crushed and cleaned until it will run about 70 per cent lead. There are some very interesting developments in flotation in progress at these mills, and nearly one-tenth of the clean ore shipped to the smelters is produced by flotation.

The resulting ore is smelted at the various plants of the different companies, located at Herculaneum, Alton and Collinsville, with a combined capacity of 250,000 tons of lead per year.

These smelters will all be visited on the occasion of the meeting.

The uses of the lead finally are interesting. Just now its tremendous importance as a war material overshadows the fact that probably one-half of the product goes into the form of white lead and other kinds of paint.

Much is used as anti-friction metal and as pipe and sheet.



METALLURGICAL PLANTS IN THE SOUTHEAST MISSOURI DISTRICT

No. 1. Mill No. 4 and Shaft No. 12 Federal Lead Co., Elvins, Mo. No. 2. St. Louis Smelting & Refining Co., St. Francois, Mo. No. 3. Shaft No. 3 Desloge Consolidated Lead Co., Desloge, Mo. No. 4. Power House and Mill, Desloge Consolidated Lead Co., Desloge, Mo. No. 5. Mill No. 3 St. Joseph Lead Co., Elvins, Mo. No. 6. Mill No. 3 Federal Lead Co., Flat River, Mo.

New York Section of Society of Chemical Industry

Colloid and Emulsion Chemistry

The New York Section of the Society of Chemical Industry held a joint meeting with the New York Sections of the American Electrochemical Society and the American Chemical Society on Friday evening, April 13, at the Chemists' Club. The chairman, JEROME ALEXANDER, presided. Considerable interest was shown in the subjects presented, the hall being crowded. A short business meeting preceded the presentation of papers.

The following officers were elected for the ensuing year by the New York Section of the American Electrochemical Society: Chairman, J. V. N. Dorr; vice-chairman, E. D. Kingsley; secretary-treasurer, J. Malcolm Muir.

Officers for the ensuing years for the New York Section of the Society of Chemical Industry were elected as follows: Chairman, Jerome Alexander; treasurer, F. C. R. Hemingway; secretary, Allen Rogers.

The first paper of the evening was presented by Dr. ALLEN ROGERS of Pratt Institute, Brooklyn, on **"Recent Advancement in Leather Manufacture."** This paper is published in full on pages 524 to 525 of this issue.

Prof. MARTIN H. FISCHER of the University of Cincinnati, presented a very interesting address on **Some Technological Aspects of Colloid and Emulsion Chemistry,** illustrating his talk with many experiments and the exhibition of many samples. He first took up the type of colloids known as suspensoids, in which a solid is suspended in a liquid. He took up the subject of water absorption by protein colloids and the effect of adding various reagents in producing or hindering swelling in proteins and carbohydrates and explained that the swelling of tissues is analogous to water absorption by proteins.

In taking up the general subject of emulsions Professor Fischer said the great question was how to stabilize an emulsion, such as, for instance, oil in water. Three methods have been proposed for doing this: (1) By adding an emulsifying agent; (2) by using a viscous liquid; (3) by reducing the surface tension, as in adding soap to water. These ideas all suffer shortcomings, according to Professor Fischer, and do not account for the action of all emulsions.

He said that all that is necessary is to have a colloid hydrate or so-called hydrophilic colloid present, which takes up the water, and thereby reduces the number of phases. An emulsion breaks whenever the hydrophilic (lyophilic) colloid which holds the aqueous dispersion means is either diluted beyond the point at which it can take up all the offered water, or is so influenced by external conditions that its original capacity for holding water is sufficiently reduced. Thus dehydration of the hydrophilic colloid can be accomplished by acids, alkalis and salts.

It is then possible, for instance, in a soap emulsion to separate out the oil by adding an amount of water so great that it cannot all be combined in the colloid hydrate. Soaps are hydrophilic in high concentration only, so we get the separation by adding enough water.

As an example of dehydration he took the system oil-water-neutral casein. These three mixed together do not form a colloidal emulsion. If we add, however, some alkali or acid and make an alkali or acid colloid hydrate, then emulsification will take place. Acid will dehydrate the alkali-casein and vice versa. There is a minimum amount of hydrophilic colloid which will give the complete emulsification. Professor Fischer illustrated this point by a number of experiments with various substances.

He explained the determination of rubber to be the cracking of the emulsion. Emulsions of oil in soap are found to have great resiliency which can be felt if a bottle of it is tapped on the table, but when cracked this resiliency disappears. Acids and various salts will crack these soap emulsions, as will also calcium hydrate and alcohol. Caustic soda will not crack them. Ether is relatively ineffective. Calcium soap is not a hydrophilic colloid, consequently the addition of calcium hydrate will crack the emulsion. The fact that alcohol and ether are by themselves thus relatively ineffective in breaking emulsions explains why the ordinary fat extraction methods are so often only partially effective in getting the fat out of biological materials, and why previous treatment of the material, as by digestion with strong acids or alkalis and by similar methods, yields higher fat figures than extraction with ether or allied materials alone.

Dr. ALEXANDER gave a demonstration of the Zsigmondy-Brownian movements, having an ultra-microscope present on the table, through which anyone who cared to could see this interesting phenomenon after the meeting.

Progress in the American Dyestuff Industry

At a meeting of the Providence Engineering Society at Providence, R. I., on Friday, April 20, Dr. JOHN C. HEBDEN, the distinguished vice-president and general manager of the Federal Dyestuff & Chemical Company, of Kingsport, Tenn., gave an interesting address on the past, present and future of the American dyestuff industry. As Dr. Hebden is the creator of the large works of the Federal Company at Kingsport, he speaks with authority. He said in part:

"At the beginning of the war the American chemist was considered to be unable to produce or manufacture dyestuffs or any of the finer chemicals. The world's production of dyestuffs was divided about as follows: Seventy-five per cent were made in Germany, or in concerns absolutely under German control in countries outside of Germany; 20 per cent were made in Switzerland or in concerns controlled by the Swiss capital. This, in spite of the fact that Switzerland possesses not one pound of coal nor one pound of raw material suitable for the manufacture of dyestuffs. The balance of the world's production was manufactured in countries outside of Germany and not under control. In this country, owing to a very unfair tariff legislation, 10 per cent of the total dyestuff consumption of the country was manufactured in the United States, and a large proportion of this product was manufactured from intermediates imported mainly from Germany.

"In spite of the handicaps under which the American chemist was obliged to undertake the manufacture of dyes, the American public immediately, at the outbreak of the war, demanded of him to do miracles and to save the country. Immediately, when he began to undertake this industry, he was confronted with an enormous demand for the raw materials which go into the manufacture of dyes from the munition manufacturers, that is, from the manufacturers of picric acid and trinitrotoluol.

"The result of this demand was that the price of benzol was from four to five times its normal price and the price of toluol from five to ten times its normal price. Therefore, he was compelled to begin the manufacture of dyestuffs from those intermediate products which would naturally be developed through the manufacture of high explosives.

"This made the development of the manufacture of dyestuffs follow parallel with the manufacture of high explosives, and during the year 1915-16 the development of a full line of so-called sulphur dyes was the result.

"These colors alone would comprise about 10 per cent of the total dyestuffs consumption of the country. Because the products used in the manufacture of some of the finer grade of high explosives could be used, a line of dyestuffs, substitutes for alizarines, but not true alizarines, were developed. Together with these colors, principally used for wool, were developed certain dyes for cotton known as the basic colors.

"All this development took place without any particular encouragement or assistance from the textile trade. The paint makers, however, realizing the seriousness of the situation, together with the ink manufacturers, started development of those products which are not used in high explosives, and produced colors used in their trades. Too much credit cannot be given to these manufacturers for their courage and their successful efforts.

"At the present time development is taking place along the line of those intermediates or products which are not so essentially a part of the high explosives business, so that the country will shortly be supplied with true alizarine, after chroming dyes for wool and for the fast acid colors for wool and the fast direct colors and developing colors for cotton. As soon as these intermediates are developed, the number of dyestuffs will be multiplied very rapidly.

"During all this development the American public has failed to realize the importance of the dyestuff industry. The propagandists representing the importers who, before the war, controlled the distribution of dyes, not only in this country but practically throughout the world, first preached the doctrine that colors could not be made in America, particularly the alizarine colors, in spite of the fact that years ago anthracine was made in this country and exported abroad and the alizarine made therefrom imported.

"The textile trade failed to realize that the people who manufactured and sold dyestuffs dictated absolutely the textile policy of the country, and while they were listening and believing those who were declaring that dyestuffs could not be made in this country, they were also listening to the argument that the dyestuff consumption of the country was a small matter anyway, and that the manufacture of dyestuffs was really a one-nation business. The result of all this propaganda was the utmost indifference on the part of the consumer, even up to the present time.

"The textile manufacturers failed to realize that economic independence is just as essential to the well-being and prosperity of the country as political independence, and, therefore, it is necessary to establish a dyestuff industry which shall supply every pound of dye which we may consume, if we are going to be able to control our textile manufacturing policy and attain our economic independence.

"The reason for the condition which confronted the American people at the outbreak of the war with reference to the supply of dyestuffs was due, first, to the propaganda, and, second, the tariff legislation. The beginning of this tariff legislation in favor of the importer dates to the patent maintained on alizarine and the insertion in the tariff in the free list of artificial alizarine. The importers found the writing of this paragraph in the tariff so easy and having made millions of dollars through their patent, were able by influences to extend not only the term 'artificial alizarine' in the free list, but to include indigo and other products so that fully one-half of the products manufactured by these concerns and imported into the United States came in duty free.

"As far as the United States was concerned, the pan-American conquest was complete as applied to dyestuffs. Since the war began a tentative revision of tariff has been made, but the same influence which dictated the previous clauses on the free list was able to dictate a joker which would nullify the benefits to be derived from tariff legislation, and place the sulphur colors, which is the largest item developed thus far by domestic manufacturers on the free list, and thus make their manufacture in this country impossible."

Dr. Hebden, in conclusion, emphasized that the development of the dyestuff industry will depend on a tariff written in favor of the American industry and not the importer. This is absolutely necessary for the sake of economic independence of the country.

The Zinc Works Pottery

By Edward Mackay Johnson

The pottery is one of the most important departments of the zinc plant, and has a very decided influence, good or bad, upon the recovery of zinc, especially with reference to making the retorts. Very close watch must be kept every day upon the operations of this department. If this is not done, serious trouble may occur on the furnaces at any time due to bad retorts; and this trouble accompanied by poor recovery will continue for the same length of time on the furnaces, as the cause of it existed in the pottery, and it is a case of having to use these poor retorts until the trouble is rectified. Even where close watch is kept upon the pottery operations, there are times when an abnormal loss of retorts occurs and disappears without anyone being able to trace the trouble.

Pottery Record.—From the preceding remarks it will be seen how important it is not only to keep an account of the retorts and condensers made, but a record should be made each day of what enters into the manufacture of the retorts, and remarks made upon the same. In this way not only will a better retort be made, but any irregularity may be more quickly located.

Very often it is only by a process of elimination that the trouble may be located. In fact this is often true of anything affecting the recovery of zinc.

PREPARATION OF THE CLAY

Most of the zinc plants still continue to obtain their supply of clay from the vicinity of St. Louis. Clays from other parts of the United States are tried now and then on a small scale for the manufacture of retorts. In a few instances satisfactory results have been obtained, and the clays used in actual practice.

Most of the St. Louis clay is well adapted to the manufacture of retorts and especially so if it be properly weathered. In fact there is no doubt but that many of the troubles arising in the manufacture of retorts, as well as the loss due to checking or cracking in the pottery and possibly in the furnace, may be traced to the improper weathering of the clay. In the writer's opinion no clay should enter the pug mill that has not been previously weathered even if the first pugging is permitted to stand for forty-eight hours before repugging. A few cents per ton expended in weathering the clay properly may save a good many dollars in the end. Due to the fact that it is almost impossible to crush and screen wet clay, it is better to have the bins ar-

ranged with roofs, and if necessary artificially assist the weathering by means of water or exhaust steam from the pottery (if it be so heated) permitting the same to come in direct contact with the clay.

After sufficient weathering the same exhaust line might be used to assist in partly drying the clay by simply closing the exhaust valves. If such an arrangement as the above could be used to advantage the pipe line would have to be laid upon the floor of the clay bin, with the exhaust valve openings extending downward and some provision made for regulating them.

ANALYSES

Tables I and II give analyses of clays from which satisfactory retorts have been made at various plants.

TABLE I—CLAY ANALYSES

	1	2	3	4	5	6	7	8	9	10
SiO_2 ..	55.7	51.0	62.2	61.7	55.4	48.3	51.4	47.4	58.7	56.0
Al_2O_3 .	29.7	35.6	31.4	29.0	34.4	31.3	30.8	35.8	28.6	27.0
Fe_2O_3..	2.7	...	...	3.0	...	...	1.8	2.4	1.6	2.4
FeS_2 .	...	...	...	...	...	1.6	1.3	...	...	...
CaO ..	0.6	...	...	...	...	0.36	0.53	0.9	0.38	0.51
MgO .	...	...	...	...	...	0.32	0.27	...	...	0.52
Alkali.	...	...	...	...	...	...	...	...	...	0.48
TiO_2 ..	...	...	...	...	...	2.00	2.35	...	...	...
S	0.3	...	...	...	...	...	...	0.88	...	...
Ig. loss	10.3	...	...	...	...	11.10	...	13.60	...	12.9

TABLE II—RATIONAL ANALYSES

Clay substitute	78.5	75.4	58.5	70.0	64.2
Quartz	17.6	14.5	22.0	24.6	10.4
Feldspar	3.8	8.4	19.5	5.4	24.9

The results are given as they were reported by various chemists at different plants.

It is seldom if ever the case that the analysis of a clay is relied upon to determine its value for the manufacture of retorts. A practical test of the retorts in the furnace is always made. The analysis merely indicates if the test is worth while making.

PHYSICAL PROPERTIES

A good clay in the lump form should have some of its surfaces smooth and should feel like soapstone. It should not feel too gritty when mashed between the teeth. If the lumps are broken open their surfaces should not show any, or at least very little, iron pyrites. Good clay should readily disintegrate upon standing in the air. After the clay is properly weathered it is crushed or rather mashed up with a jaw or hammer type of crusher and elevated to some type of screen, the returns going to rolls. The same screen is used for the clay that is used for the adobes[1], which seldom varies much from a 6-mesh No. 16 wire. In some plants the clay and adobes are crushed separately, and at some they are crushed together in proper proportions. So far as the retort is concerned it is immaterial, provided the proper mix of the ground clay and adobes be charged into the pug mill. The proportion of raw clay to burnt clay varies somewhat according to the physical character of the two substances. As a rule a little more burnt clay is used than raw clay, about 70 parts to 60 parts.

The same machinery used to prepare the clay, including the 6-mesh No. 16 wire screen, serves to handle the burnt clay or adobes as previously stated. Actual practice has demonstrated that it does not pay to get very far away from this size screen. One of the main points to bear in mind is to avoid forming much fine material, especially with respect to the burnt clay, by having ample screening capacity and possibly two sets of rolls.

As the tests of Table III were made at two different plants under different conditions there is naturally a

[1]The term adobes here used refers to burnt clay or clay mixed with grog and burnt. The term also refers to what is called chamotte, grog or cement. All of these terms are used indiscriminately at the different plants.

TABLE III—SCREEN TESTS ON CRUSHED ADOBES

Mesh	No. 1 6-Mesh No. 16 Wire, Per Cent	No. 2 6-Mesh No. 16 Wire, Per Cent	No. 3, Piano Wire, Per Cent
On 8.....	3.00	....	...
On 10.....	....	16.00	30.8
On 20..	55.02	25.90	28.5
On 30.....	....	26.70	13.5
On 40.....	21.11	7.30	6.5
	79.13	75.90	79.3
On 60.....	8.81	6.60	4.5
On 80.....	2.51	5.90	6.8
On 100.....	1.51	2.10	3.0
Through 100.....	8.04	9.60	6.4
	20.87	25.10	20.7

variation in the results. It is, however, interesting to note that the sum of the material above the 40-mesh screen is very nearly the same in the three cases and that considerable material passes through the 100-mesh screen. It might be well to make an analysis of this very fine product to see if it does not carry a large proportion of the impurities. If so, its removal by suction might make it possible to produce a better retort.

PUGGING

Provided the clay and adobes have been crushed to the proper degree of fineness, it is merely a matter of practical experience and judgment to be able to add the requisite amount of water to obtain the correct temper of the retort mud. The first pugging should stand for at least twenty-four hours (even if the clay had been previously weathered) before pugging the second time. It is customary to endeavor to have the first pugging just soft enough so that when it is pugged the second time the mud will become stiff enough for the retorts without the addition of either water or mix.

MAKING THE RETORTS

Most of the plants have replaced the common retort press with the hydraulic retort press. It is interesting to note, however, that two of the new plants have installed the former; and in one of these cases it was said to have been based on obtaining better results with the common retort. The writer has been connected with three plants that used the common retorts, and three that used the hydraulic, and has come to the conclusion that if a solid foundation be put in, the iron frame work made heavier, and all the parts of the press kept in proper alignment, the common retort may be made practically as good and a little cheaper than the hydraulic pot. With respect to the recovery of zinc, and tonnage handled by the two kinds of retorts, no figures of comparison can be given as no similar conditions existed in any two cases.

DRYING RETORTS

In the construction of some of the potteries in recent years, the old plan of having two or three large drying rooms one above the other, and transferring the retorts several times in order to dry them slowly, has been abandoned in favor of smaller and more rooms constructed adjacent to each other on the ground floor. The main advantages of this system are as follows: The retorts are handled less, as they are taken direct from the press to these rooms and remain there until taken to the furnaces. The rooms are not so much subject to change in temperature, or drafts. The temperature and drying are more easily controlled.

In either case the drying must be done by degrees, and the retort thoroughly dried. There is no apparent reason why retorts should improve with age, provided they are once properly dried; but as a safe precaution it is best not to use them before they are thirty

days old. One of the most important things to bear in mind, but which is often neglected, is the proper drainage from underneath the pottery floor. Another is that frequently not enough space is left between the ground floor proper, and the floor upon which the retorts set, so that any leaks occurring in the steam or water lines may be readily repaired.

RETORT COST

Apparently the cost per retort has not changed very much in the past ten years, while in reality it has, due to some increase in labor. The quality of the retort should always be the first consideration. This subject will be taken up again under pottery cost.

SIZE AND CAPACITY OF RETORTS

In order to show how the retorts vary in measurement, and therefore in cubic contents, Table IV gives the figures on dried retorts. They represent the average of a number of measurements of retorts at five different plants. The figures given for diameter and length are inside measurements.

TABLE IV—RETORT DIMENSIONS

	Diam., In.	Length, In.	Wall, In.	Butt, In.	Kind	Cu. Ft. Capacity
No. 1.....	8¼	45.3	1 3/16	2½	Common	1.360
No. 2.....	8½	48.0	1 3/16	2½	Common	1.576
No. 3.....	7¾	49.4	1 1/16	1½	Hydraulic	1.349
No. 4.....	8 3/16	50.5	1 1/16	1½	Hydraulic	1.539
No. 5.....	8 3/5	49¼	1 1/16	1½	Hydraulic	1.656
Average..	8 3/16+	48½	.....	...		1.496

In expressing furnace capacity the term "pounds of ore per furnace" or per retort does not mean very much, and as the following illustration shows it would be more accurate to use the term "pounds of ore per cubic foot of retort or furnace capacity." Assume a plant of ten furnaces and 4000 retorts. Assume 33 lb. of roasted ore per cubic foot. Then taking the highest and lowest cubic foot retort capacity in table IV we would have:

Retort Capacity, Cu. Ft.	Total Retorts	Plant Capacity, Cu. Ft.	Lb. Per Cu. Ft.	Lb. Per Furnace	Lb. Per Plant
1.360	4000	5440	33	17,952	179,520
1.656	4000	6624	33	21,859	218,592

This shows a difference of nearly 4000 lb. of ore per furnace; wherefore if any very accurate comparisons are to be made between capacities of two furnaces, blocks or plants, it is necessary to know the retort capacity in cubic feet.

CONDENSERS

Nearly all of the plants have installed condenser machines, of which there are two types. As the highest cost per condenser rarely exceeds 5 cents there is very little room for reduction. Sometimes a cheaper grade of clay is partly or entirely substituted for the retort clay in the manufacture of condensers. The grog consists principally of the cleanest of the retorts from the furnace. There is not so much difference in the shape of the condensers at the different plants, as there is in the length. The variation in size would be as stated in Table V:

TABLE V

	Inches
Outside diameter of large end	7 to 7½
Inside diameter of large end	6¼ to 6⅝
Outside diameter of small end	4¼ to 4⅝
Inside diameter of small end	2⅝ to 3⅛
Thickness of wall	¾
Length	17 to 20

These measurements refer to the sizes obtaining at the five plants for which the retort dimensions were given.

CONDENSER LOSS AND EFFECT

An abnormal loss of condensers on the furnaces often arises, and it is difficult to determine whether it is due to the condenser itself or to the character of the luting material used to close the space between the condenser and retort, or to the carelessness of the men in handling the condensers. As a rule, however, the loss is held to about one condenser per day to every 11.5 retorts in the furnace. Assuming a 4000-retort plant the condenser loss would be about 350 per day, which at 4c. apiece would mean $14 or 12c. per ton on the basis of treating 120 tons of green ore per day.

LOSS DUE TO EFFECT ON ZINC RECOVERY

The test of Table VI was made with a view of ascertaining this loss.

TABLE VI

No. of Condensers Changed	Total Weight, Lb.	Av. Weight Per Condenser
8	170	21
8	187	23
10	246	...
10	272	27.2
9	276	30.6
10	277	27.7
10	272	27.2
10	284	28.4
9	238	26.4
10	290	29.0
Total 94	2512	...

Average weight for condenser, 26.72 lb.

After weighing the condensers the scales were set at the average weight, and every one of the ninety-four most nearly approaching this weight was set aside for a sample. In this way nine condensers were obtained. They were broken up fine, quartered, sampled and assayed, showing 35.5 per cent zinc.

Then $2512 \times 0.355 = 891.76$ = lb. zinc in 94 condensers, and $891.76 \div 94 = 9.487$ = lb. zinc in 1 condenser. If we again assume a 4000-retort plant changing 350 condensers per day we have $350 \times 9.487 = 3320$ lb. zinc in condensers. If in retreating this material we lose 10 per cent our loss would be 332 lb. of zinc per day, or $16.60, with spelter at 5 cents per 100 lb., or about 14 cents per ton of green ore. The total loss from condensers would therefore be 12 cents + 14 cents = 26 cents per ton of green ore.

FURNACE MUD

In addition to making the retorts and condensers, the pottery department is required to pug the furnace mud and make any miscellaneous tiles used around the plant, but as a rule the tile for the furnace lining is purchased. The furnace mud is used for stamping up or closing any openings between the retorts or about the furnace in general. The mud is made as cheap as possible consistent with the purpose for which it is used. It should be made rather lean so that it will not burn too hard, making it difficult to cut out.

It is well to know the following facts with respect to the pottery:

Weight of ground clay per cu. ft.
Weight of ground adobes per cu. ft.
Weight of green retort.
Weight of dried retort.
Weight of burnt retort.
Weight of clay in retort.
Weight of adobes in retort
Weight of clay in condenser.
Weight of adobes in condenser.
Shrinkage of retorts and condensers in drying.
Shrinkage of retorts and condensers in burning.

POTTERY COSTS

The comparisons in Tables VII, VIII, IX, X, taken from two natural gas-field plants, and two coal-field-

plants, give a fair representation of the labor cost of a pottery. As the condensers are nearly always made by contract they will not be considered.

TABLE VII—GAS-FIELD PLANT MAKING COMMON RETORTS

		Per Day of 9 Hours
1	Foreman	$2.50
1	Retort man	1.75
1	Retort feeder	1.60
1	Retort setter	1.50
2	Pug mill men, @ $1.70	3.40
2	Pug mill men, @ $1.60	3.20
1	Mud piler	1.50
1	Crusher man	1.50
1	Wheeler	1.50
1	Retort trammer	1.60
12		$20.05

TABLE VIII—COAL-FIELD PLANT MAKING HYDRAULIC RETORTS

		Per Day of 9 Hours
1	Foreman	$3.00
1	Press man	2.00
1	Hammer man	1.90
1	Trimmer	1.80
1	Setter	1.75
1	1st Pug mill man	2.00
	2nd Pug mill man	1.85
2	Pug mill men, @ $1.75	3.50
1	Crusher man	1.85
1	General man	1.75
11		$21.40

TABLE IX—GAS-FIELD PLANT MAKING HYDRAULIC RETORTS

		Per Day of 9 Hours
1	Foreman	$2.50
1	Press man	2.50
1	Schlagger	2.30
1	Pug mill man	1.75
1	Pug mill man	1.60
1	Pug mill man	1.50
1	Wheeler	1.50
3	Roustabouts, @ $1.50	4.50
10		$18,15

TABLE X—COAL-FIELD PLANT MAKING COMMON RETORTS

		Per Day of 9 Hours
1	Foreman	$4.00
3	Pug mill men, @ $1.90	5.70
1	Retort maker	2.00
1	Retort setter	1.80
1	Finisher	1.80
1	Crusher man	1.80
1	Wheeler	1.80
1	Trammer	1.80
1	Laborer	1.75
11		$22.45*

*Afterwards reduced somewhat.

It will be seen that eleven men and $20 per day are required to carry on the operations of a pottery with respect to the fabrication of the retorts and that the cost per retort depends upon the number of good ones that can be put through the press in nine hours' time. It is due principally to this fact that in the past the cost of the hydraulic retort has been somewhat higher than the common. This difference, however, is being reduced from time to time.

The items making up the 50 cents per retort based upon using 60 parts of clay to 70 parts of adobes are about as follows:

Clay	$0.0657
Adobes	0.1220
Supplies	0.0440
Labor	0.2526
Total	$0.4843

Henryetta, Okla.

Chile as a Field for Manufacturing and Investment.—In order to acquaint our business men with the industries of Chile and to explain opportunities that exist there, a lecture was given by Hon. Senor Jose A. del Campo, commercial delegate of the Chilean Government and Consul of Chile, in Mobile, Ala., at the Waldorf-Astoria on March 29. The lecture was given under the auspices of the National Association of Manufacturers.

The Relation of Research to Everyday Life*

By Dr. J. B. Weems

Chief Chemist, Department of Agriculture of Virginia.

The investigator upon any problem connected with science is like the pioneer in a new country. Unseen obstacles may be met without warning at every point, and it is only those who have determination and who will make the sacrifice reach the goal.

Research may be defined as a diligent inquiry or a search after a desired object. In order that research may be of value those engaged in the work must be well equipped and the conditions made favorable to success. The conditions which will encourage research are well worthy of the most careful study on the part of those interested in the advancement of education and knowledge.

It will be recognized that those fitted for research are born with certain characteristics and this birthright brings to them an inherent ideal for the work. The heritage does not, however, carry with it the ability to seek out the unknown in the absence of the proper training. Both the heritage and the training of the faculties must go hand in hand to insure success.

The late President Gilman of the Johns Hopkins University tells us in discussing the characteristics of a university that, "Nobody can tell how it comes to pass that men of extraordinary minds are born of commonplace parentage and bred in schools of adversity away from books and masters. Institutions are not essential to their education. But every one who observes in a series of years the advancement of men of talents, as distinguished from men of genius, must believe that the fostering diet of the university—its 'plain living and high thinking'—favors the growth of scholars, investigators, reasoners, statesmen of enduring reputation, poets and discoverers. Such men are rarely produced in the freedom of the wilderness, in the publicity of travel or of trade, or in the seclusion of private life; they are not the natural product of libraries and museums, when these stand apart from universities, they are rarely produced by schools of the lower grade."

One of the necessary conditions which favors success in research is that one who undertakes this chosen field of labor must be a learned man, equipped and trained in order that he may be master of his special field of work.

It is naturally required that he know the past history of what has been done as related to his subject, and with this as a foundation a knowledge of what is being accomplished in associated fields at the present, he can select with judgment a field of work which in due season will yield results of value for the future years.

In these days when each field of knowledge is so vast that only a part can be mastered by any individual, there is a very strong tendency indeed for the average person to become restless and desire to enter at once into the work of research without the necessary equipment or training.

This necessary training and understanding as a preparation for research is only realized by those closely connected with scientific work. The general conception of scientific investigation has been well stated by Wells in his lecture on "The Discovery of the Future," delivered before the Royal Institution, as follows: "The popular idea of scientific investigation is a vehement, aimless collection of little facts, collected as a bower bird collects shells and pebbles in methodical little rows, and out of this process, in some manner unknown to the popular mind, certain conjuring tricks—the celebrated 'wonders of science'—in a sort of accidental way emerge.

*An address before The Virginia Chemists Club, Richmond, Va.

The popular conception of all discovery is accident. But you will know that the essential thing in the scientific process is not the collection of facts, but the analysis of facts. Facts are the raw material and not the substance of science. It is analysis that has given us all ordered knowledge, and you know that the aim and the test and the justification of the scientific process is not a markable conjuring trick, but prophecy."

The term popular is applied to anything intended for presentation to the general mass of our neighbors, who we sometimes forget have not had the opportunity of becoming familiar to any extent with science. It is true that the public have from time to time the privilege of hearing a course of lectures on scientific subjects in a popular manner and naturally it is very difficult to realize that they should have anything else but a very vague idea of science. The scientific man too often neglects the opportunity of presenting to the public the results of his labors. Many times this presentation of science is left to a select few of the order of Squeers, as created by Dickens in "Nicholas Nickleby." "Measles, rhumatics, hooping cough, fevers, agers, and lumbagers," said Mr. Squeers, "is all philosophy together; that's what it is. The heavenly bodies is philosophy and the earthly bodies is philosophy. If there is a screw loose in a heavenly body, that's philosophy; if there is a screw loose in a earthly body, that is philosophy, too; or it may be that some times there's a little metaphysics in it, but that's not often. Philosophy is the chap for me. If a parent asks a question in the classical, commercial or mathematical line, says I, gravely, 'Why, sir, in the first place, are you a philosopher?' 'No, Mr. Squeers,' he says, 'I ain't.' 'Then, sir,' says I, 'I am sorry for you, for I sha'n't be able to explain it.' Naturally, the parant goes away and wishes he was a philosopher, and, equally naturally, thinks I am one."

Much of the so-called popular science that is given to the masses has little science connected with it. As Le Bon states in speaking of the psychology of the crowd, "Affirmation pure and simple, kept free of all reasoning and all proof, is one of the surest means of making an idea enter the minds of crowds. The conciser an affirmation is, the more destitute of every appearance of proof or demonstration, the more weight it carries."

"Science as she is taught" might make a very interesting subject for investigation in its effects upon the popular mind. The result would give us some interesting psychological data, to say the least. It has been said of our schools: "Common schools is a splendid term, common is a splendid word, but there is such a thing as commonplace." Is not the science that the public gets commonplace?

Then again we have that peculiar phase of education that is of the nature of a tea party or along the lines of least resistance. As Mr. Dooley has said in his characteristic manner in speaking of the student's entrance on his college career: "Th' prisident takes him into a Turkish room, gives him a cigareet an' says: 'Me dear boy, what special branch ov learning wud ye like to have studied f'r ye be our compitint professors?' "

From the popular view of the young student the word research has something of wonder in it like unto that of the mystery of the olden times of the alchemist or the wonderful philosopher's stone which had the power to change the baser metals to the rarer ones of gold and silver. The word research is the mysterious key word to open the hidden treasures.

The memory brings before me the application of a very young student who wanted to enter college and take up research in chemistry. When asked as to his course of study it was stated that he had studied chemistry for six months and that in addition he had charge of the store room at the school at the same time. On further questioning as to the book used for instruction, the title or the author of the book that had been used as a textbook could not be stated by the student, and as a last resort the statement was made that it "was a green book."

The student is not entirely responsible for this condition, but many who should know better mislead him too often. With the faith that is characteristic of the pupil in his teacher, he receives a very visionary idea of research, as may be shown from some of the recommendations given to students. The following may illustrate the manner in which some recommendations are given under such conditions:

"His particular work, aside from analytical work, has been the care and conduct of the State Food Exhibit, and he has done good research work in the taking of ice-cream samples, which has been of great value to the department."

The next consideration of interest in connection with research is that of the chemist and his personality. In this relation we have two views presented to us, that of the university, and that of the practical field of work.

In the university the atmosphere or spirit of the institution is in a large measure a determining factor in the grade of research work. The president of the institution controls to a great extent the conditions that may be present.

It has been stated by President Thring that "The college president cannot be one who produces original work in the college, as his position is that of an executive, but it is within his sphere to recognize the ability of those engaged in research work in the institution, and to see that proper conditions are supplied for this part of the advancement of education. It is well recognized that buildings, while necessary, do not make the college or university, and complicated apparatus may require so much care that there is little time that remains for other work. Even well planned buildings and a splendid equipment of apparatus do not insure the production of a high grade of research. Men are the essential feature in this special sphere of education.

It has been told of Agassiz that when asked why he did not make use of his ability to make money, he replied that he did not have the time for making money. If this ideal is held in an institution it becomes a responsibility on part of the public interested in the institution that the salary attached to the position is such that the problem of making both ends meet is not a difficult one. The plain living and high thinking may be advantageous under certain conditions, but sometimes the plain living is very much plain and very little living, and as a result there is very little high thinking. In other words, a man cannot devote his energies to high thinking if the funds for paying the bills for ordinary living are lacking.

A normal, well nourished boy is necessary as well as a well equipped mind for the production of a normal result. Can an investigator with a body that does not receive proper nourishment, under a nervous tension from unpaid bills and matters of a similar nature, carry out a piece of research work? It has no doubt been done again and again, but only by not meeting the obligations of life in a business manner.

In this connection the question may be asked, Is there not a responsibility to the public in connection with the field selected for research? Has the investigator the right to select a subject that is largely a matter of personal interest, or a hobby, if you please, and spend his time as well as the time of his students on such a subject, resulting in publication after publication of interest to only a select few or to only a very small group at

least? It is well to bear in mind that only a select few of these students can spend their lives on research and that to them the study is a bread and butter problem as well as their interest in the work as an equipment for educational training.

There is no doubt that the field of reasearch in practical lines will give splendid results. We have not had the co-operation which should exist between the practical business man and the scientific investigator. One has regarded the other as a visionary impractical person incapable of business capacity, and the other has regarded the first as simply a dollar grasper, one who even dreamed of dollars and the methods of getting them. The fact of the case is that both are to a certain extent right and both wrong to a certain extent. The practical business man needs more scientific knowledge about his factories and the scientific man can learn much from the business man and a little knowledge of business methods, and incidentally a few more dollars will broaden his horizon rather than narrow it.

We need more followers in the steps of Liebig. Those who can undertake a scientific investigation and at the same time show a thoroughly scientific interest in the welfare of the masses. Liebig had this faculty, as may be shown by his wide knowledge and investigations in many lines and at the same time having time and interest to write his "Familiar Letters on Chemistry." It is said that the results of his work of this nature are seen in the present intelligent attitude of the German "practical man" to science, which has contrasted so strangely with that of his English brother for many years past.

We hear many complaints of the confining hours of the laboratory in the present day, but when we are told that in Liebig's laboratory "work went on from daybreak till nightfall. There was no amusement and no dissipation to be had in Giessen, and the only complaint, which was a frequent one, was that of Aubel (the laboratory man), who could not get the workers to depart in the evening when he wanted to clean the room."

Liebig left to Germany a heritage in chemistry, and this she has developed in a wonderful manner. Let us listen to the message from Maximilian Toch as given in *Science* recently: "Many a chapter has been written on the regeneration of Germany. Where once barren fields stood, so barren that foodstuffs would not grow, there has risen vast works, bristling with vast stacks of factories and thousands of commercial flowers grow where once not even a weed would flourish. And in all of these plants chemists are working, controlling the products that are made and creating new things, and for every new and useful compound more work is found. Whereas 30 to 50 years ago, its best people left it like rats from a sinking ship, to-day many are immigrating, for it is a flourishing land, which chemistry has retrieved. Germany was always poor up to 10 or 15 years ago (written in 1909). With two or three possible exceptions no vast industries existed, and it had nothing to export, but to-day its exports are enormous, its people prosperous, in comparison with its neighbor, Austria, where industry is making slow progress."

Since the above was written we have seen as the result of the war how great an influence the chemical industries of Germany have had on the industries of other countries. Contrast with England, if you please, where the science of chemistry has been given little or no encouragement. Has America inherited its dilatory habits for the encouragement of chemistry from England? It is a question well worth our consideration, and if possible let America awaken to this fact before we have the experience which has been so ably stated by Prof. Armstrong recently in the London *Times*, as shown by the following extract from *Science*, July 23, 1915:

"Though I have fifty years' experience as a chemist, particularly in connection with the materials now being used in the manufacture of explosives and of natural and artificial organic products, I have never been consulted; and the only request for my assistance that I have received, since the outbreak of the war, came from a German gentlemen, long since naturalized as a British subject. No doubt I am properly regarded as merely a retired professor, but I know highly competent younger men among those trained by me who are equally unutilized.

"Sir Joseph Larmor pointed out in your issue of March 29 that the country has no use for chemists. Yet we read in the daily papers that the chemist is the people's darling in Germany, and that the war is a war of chemists. We know that it will be in industry when the fighting is over. But in a country which is dominated by the lawyer-politician, in which, to use Matthew Arnold's expression, the idea of science is unknown, it cannot well be otherwise. We shall continue to muddle along, having reformed Oxford; we have changed our school masters and the idea of science is abroad: it is perhaps fortunate that it is fast being hammered into us by the high explosive shell."

In conclusion let us consider some of the needs of our country: (1) We need a great awakening as to the possibilities of chemistry in our industries and a realization on the part of the business man of what the science can do for the developing of the country. (2) We want a great awakening on part of the scientific investigator as to the great possibilities of the application of chemistry to the industries and the great field for the application of research. (3) We want a great awakening as to the value of men of character and training in the industries, not slaves of the test tube, but men with the ability to direct and control the industries along scientific lines. (4) We want a great awakening to the fact that we have been paying too much attention to dividends based on the dollars and not on the future development of our country. We have prided ourselves on how cheaply we produced regardless of how we ground the men. We have placed the chemist on par with the laborer and have not appreciated the training necessary for the proper work of the chemist. We have tried, not to get the best trained men, but how cheap we could get them. (5) We want a great awakening among the wealthy men in order to realize the value of institutions for practical research work like that of the Mellen Institute at Pittsburgh. Every State could use such an institution to its utmost capacity in developing its industries. (6) We want a great awakening for a square deal for the chemist and an opportunity for him to show what can be done for the country. This means fair returns for his labor, an appreciation of his value to society, and a chance to take his place as a business man in the business management of the industries.

Will the sleeping giant which we call "the business world" awake to the opportunity before him or will he sleep on to his destruction and the loss of the chance to make the most of the country? This is the question.

Richmond, Va.

The Kwagaku Kogei or *The Chemical Technology*, is the title of a new Japanese journal edited by Prof. Dr. H. Nishida. The first issue appeared in January, 1917. There are 106 pages of text, of which four are printed in English (reproduced on pages 505 and 506 of our present issue) and 102 in Japanese; among the illustrations in the latter we recognize the coal-tar tree and a portrait of Dr. Baekeland. There are 24 pages of advertisements. We extend our best wishes for success to this first Japanese chemical journal.

Spring Meeting of the American Chemical Society at Kansas City, Mo.

The meeting held by the American Chemical Society from April 10 to 14 in Kansas City, Mo., with headquarters at the Hotel Muehlebach, might well be termed a preparedness meeting. If it is considered that this meeting came near being called off by the president of the society, the attendance was remarkable, numbering approximately 400. The meeting place for the gathering of so many chemists was very fortunately chosen as it gave an opportunity for the members from other parts of the Union to see the possibilities of the great Middle West, of which Kansas City may well be called the center and the resources of which will be mentioned later.

The country is at present facing a crisis. The minds of the people in general are on edge. At no time, since the founding of national engineering and scientific societies, has it been of such paramount importance to hold meetings and give exhibits as now, for it is a necessity to bring before the public the natural, the intellectual and the commercial resources of the nation. Nothing eases the mind so much as to know that in an emergency of this kind the natural and industrial resources are in adequate shape of being utilized to guarantee the safety of the nation.

The meeting was officially opened on Tuesday, April 10, at 6.30 p. m., by a banquet tendered to the Council of the society at the University Club. Wednesday was opened with a general meeting, followed in the afternoon by a public session on Petroleum and Natural Gas. Thursday morning was devoted to a Symposium on the Chemistry and Metallurgy of Zinc. The rest of the time was taken up by the reading of the various papers before the individual divisions and by trips around the city and to neighboring industrial and metallurgical plants of interest. The number of papers read before the society was 136. They were distributed as follows:

Public Session on Petroleum and Natural Gas	7
Symposium on the Chemistry and Metallurgy of Zinc	8
Industrial Chemistry and Chemical Engineering	14
Physical and Inorganic Chemistry	22
Organic Chemistry	19
Agricultural and Food Chemistry	15
Biological Chemistry	33
Water, Sewage and Sanitation	5
Pharmaceutical Chemistry	13
Total	136

Few if any criticisms can be made regarding this meeting, but two suggestions are certainly in place. First of all, it is absolutely essential that the papers offered before the meeting should be in the hands of the members at least a month before the meeting takes place. This is a necessity, as only through the knowledge of the subject treated is a satisfactory discussion possible, and after all the discussion is vital for the production of new thoughts and ideas. With the vast number of papers and subjects offered at such a meeting it is essential, that each member know before hand what he wishes to hear and to discuss. That can only be accomplished satisfactorily by giving into the hands of the members the original papers or at least abstracts of the papers previous to the meeting. Under present conditions the general trend of discussions was rather slow and lacked animation.

The second suggestion is that, especially in times as the present, there should be exhibits of local products

PHOTOGRAPH TAKEN AT BANQUET OF AMERICAN CHEMICAL SOCIETY AT KANSAS CITY

or products from the near vicinity. It is of interest to know what the locality can furnish in time of need. Exhibits of the oil refineries, the electrolytic galvanizing plant, packing houses, paper mills, soap factories and many other concerns would have more clearly enlightened the possibilities of the district than any number of papers could have done. Let people actually see the crude materials and the finished products from any certain section of the country where national meetings are held.

The Council Meeting

In a preliminary council meeting PROF. W. A. WHITAKER suggested a special division on metallurgy to be incorporated in the society. Unfortunately this recommendation was not passed.

The resolutions taken and passed in the regular council meeting were: that a committee be appointed to deal with the co-operation of the industries and universities. At the suggestion of DR. W. F. HILLEBRAND a committee was appointed to insure greater purity of reagents necessary in chemistry and in the industries. Local sections and divisions have no authority to publish or issue any resolutions or official actions on matters of national importance. A committee comprising the president, the secretary, the two most recent past presidents and two councillors at large were appointed to act for and on behalf of the American Chemical Society in matters of national importance. It was also resolved that a plea be made to the ladies of the nation to refrain from buying jewelry set in platinum, and that platinum should not be used in photography. This action was taken to conserve this valuable metal for more stringent uses during the state of war, as the supply in this metal is very low in the United States.

The next meeting of the society will be held at Boston, Mass., in the week opening Sept. 10, 1917. Invitations from Philadelphia and Cleveland were received for the spring meeting in 1918, but no action was taken on the matter.

Opening Meeting

The Wednesday morning meeting was opened by Prof. W. A. WHITAKER, who mentioned in his speech the potential importance of Kansas City along the line of chemical industries. The representative of the Mayor of Kansas City followed with some statistics regarding the city. Kansas City is first in the manufacture of Pullman cars, handling of hay, yellow pine and farming materials; second in handling meat products, grain, live stock and mules; third in lumber, flour and the poultry trade; fifth in banking and seventeenth in population. It is interesting to know that eighteen trunk lines enter the city and that 260 passenger and 1500 freight trains pass through Kansas City per day. The city also has 70 miles of boulevards and parks. Without any doubt Kansas City is one of the greatest centers of production in the Middle West.

DR. F. STRONG, chancellor of the University of Kansas, then made the welcome address. In a very interesting manner Chancellor Strong brought to the attention of the members the possible effect of the war on the universities and colleges of this country. Had we not entered this war, the speaker claimed, the United States of America would have led the nations in universities and colleges. If, on the other hand, this war lasts any length of time, it will take ten to twenty years to get back to our present standing. Hope was also expressed that the food situation may be regulated. A great and important sentiment in true Kansas progressiveness was voiced by Chancellor Strong when he expressed the hope after this war all party politics be eliminated and this nation have a national government, the state governments to be abolished as ineffective and wasteful. From the applause the speaker received it may be judged that many of those present agreed with him on the subject.

DR. JULIUS STIEGLITZ, president of the American Chemical Society, accepted the proffered hospitality on behalf of the society. He briefly stated the duty of the society to the country and elaborated on what the individual could do. The latter should offer the best that is in him. For the successful termination of the war as far as the United States is concerned, it is necessary that all preparations be conducted on a scientific basis and that brains be saved at the sacrifice of brawn. The chemist is a necessity to the country, and he is of more value alive than dead.

ARTHUR J. BOYNTON then read a paper entitled: **The Economic Resources of the Kansas City Zone.** This zone involves Kansas, Oklahoma, and Missouri. The whole zone grew up, as one might say, with Kansas City. As a railroad center Kansas City is second only to Chicago. It is the center of the Southwestern oil and zinc fields. Agriculturally it is one of the big centers of the United States. Kansas City is the center of the tenth national bank district. The natural gas

TABLE I—PAPER OF ALLEN AND LYDEN

Location	(1)	CO_2	HHC	O_2	CH_4	C_2H_6	Res.	B.t.u.
Augusta, Kan.	..	0.13	0.00	0.00	10.54	1.64	87.69	129
Cowley Co., Kan.	..	0.13	0.00	0.37	16.27	3.01	80.23	209
Chautauqua Co., Kan.	..	0.30	0.00	0.18	42.38	1.85	55.29	441
Chautauqua Co., Kan.	..	0.00	0.00	0.40	49.01	3.89	46.67	541
Ellsworth, Kan.	..	0.30	0.23	0.09	61.09	1.09	37.20	609
Ponca City, Okla.	..	0.05	0.00	0.40	44.60	14.86	40.10	688
Kay Co., Okla.	..	0.21	0.32	0.00	57.91	9.89	31.65	735
Chautauqua Co., Kan.	..	0.55	0.00	0.81	85.53	0.15	12.95	839
Chautauqua Co., Kan.	..	0.11	0.59	0.98	79.13	7.79	11.39	894
Butler Co., Kan.	..	0.00	0.71	0.14	62.15	18.38	18.64	930
Montgomery Co., Kan.	..	0.24	0.24	0.25	83.04	8.54	7.95	970
Blackwell, Okla.	..	0.00	1.18	0.16	70.69	18.65	9.32	1025
Cushing, Okla.	..	Tr.	0.12	Tr.	70.74	21.64	7.49	1059
Bartlesville, Okla.	..	0.24	1.21	0.24	70.50	24.60	3.21	11 25

TABLE II—OKLAHOMA GASES

Pawhuska	3	0.77	0.15	0.62	90.90	5.40	2.40	971
Cushing	5	Tr.	0.12	Tr.	70.74	21.64	7.49	1059
Cushing	2	0.83	0.42	0.42	67.26	18.98	12.14	984
Bigheart	3	0.86	0.15	0.30	78.90	16.43	3.34	1048
Hominy Creek	2	0.16	0.46	1.07	79.09	11.47	7.76	970
Hominy	2	Tr.	0.00	Tr.	75.65	8.69	15.52	881
Bartlesville	7	0.13	1.03	0.39	72.02	21.16	5.29	1078
Hogshooter	5	0.14	0.83	0.10	73.07	20.63	5.23	1075
Hogshooter	2	1.55	0.00	0.39	91.82	2.35	3.98	927
North Osage	8	0.40	0.80	0.54	72.64	13.62	11.88	950
Wann	4	0.48	0.49	0.32	76.66	16.26	5.80	1029
Wagner County	1	1.60	1.53	0.36	69.01	17.31	10.17	991
Blackwell	14	0.00	0.32	0.47	71.40	20.13	7.76	1043
Blackwell	1	0.05	0.10	0.11	60.54	6.22	32.97	690
Ponca	5	1.00	0.23	0.00	84.16	7.53	7.08	947
Ponca	1	0.05	0.00	0.40	44.60	14.86	40.10	688

TABLE III—KANSAS GASES

Augusta	32	0.00	0.71	0.14	62.15	18.38	18.64	930
Sedan	13	0.00	0.00	0.40	49.01	3.89	46.67	541
Sedan	6	0.30	0.00	0.18	42.38	1.85	55.29	441
Arkansas City	2	0.00	0.38	0.10	67.36	14.68	17.46	908
Arkansas City	1	0.00	0.43	0.00	73.28	17.10	9.18	1006
Allen County	1	0.35	1.15	0.39	79.80	4.33	14.00	865
Winfield	5	0.36	0.00	0.24	77.90	9.51	11.98	912
Havana	2	0.00	0.45	0.20	72.56	13.46	13.34	955
Benedict	1	0.12	0.00	0.46	92.30	.....	4.30	900
Ellsworth	3	0.33	.....	0.15	60.43	3.41	35.77	639
Winfield	7	....	0.37	0.12	76.24	10.52	12.72	920
Chanute	7	0.73	0.24	0.02	90.86	2.91	5.23	932
Fredonia	10	0.67	0.24	0.31	91.40	2.41	4.96	924
Humboldt	6	0.72	0.49	0.24	92.92	2.52	3.11	944
Neodesha	4	0.73	0.24	0.24	84.86	6.88	7.02	943

(1)=No. of samples.
No. 8 from 530-foot sand; No. 9 from 580-foot sand.
All B.t.u. above are calculated to 0° C. and 760 mm. pressure from the following values: Heavy hydrocarbons (HHC), 1627; CH_4, 966; C_2H_6, 1728.

AUGUSTA FIELD

Shallow gas	..	0.13	0.00	0.00	10.54	1.64	87.69	129
Varner No. 2	1	0.00	0.27	0.00	44.63	9.49	45.50	809
Wilson No. 1	2	0.07	0.19	0.19	63.92	5.67	39.96	719
Carter No. 1	2	0.00	0.00	0.00	60.10	9.53	30.36	745
Foster No. 3	4	0.00	0.00	0.50	49.60	21.31	28.59	847
Moyle No. 1	..	0.29	0.33	0.29	69.67	15.25	14.16	942
Love No. 1	..	0.13	0.13	0.00	71.64	18.72	9.37	1013
Varner No. 2	..	....	....	0.00	78.54	20.00	4.45	....

CHEMICAL BUILDING, UNIVERSITY OF KANSAS

ONE OF THE CHEMICAL LABORATORIES

resources offer the zone a cheap fuel and permit such industries as zinc, cement and glass to prosper on a large scale. Other industries of interest are: the gypsum industry, gypsum being used for paint, plaster and cement; the salt industry, both rock salt and brine being handled in the ten plants now in operation. Finally clay products play an important role in this zone. Undoubtedly few of those present realized the importance and one was impressed by the remarkable activity of the district. Besides the many industrial plants, such as refineries, soap factories, tanneries, etc., one factor leading to success must be mentioned, namely, the co-operation of the railroads with the district. This is a fine example to certain Western cities which are suffering in their development due to the lack of said co-operation.

Public Session on Petroleum and Natural Gas

Wednesday afternoon was devoted to a public meeting on petroleum and natural gas. Dr. H. P. CADY was chairman.

The first paper presented was by RAYMOND C. MOORE on **The Geology of the Mid-Continental Oil and Gas Fields.** This was briefly discussed.

The second paper, **Variations in the Composition of Gases of the Mid-Continental Oil and Gas Fields,** was presented by H. C. ALLEN and E. E. LYDER. This comprised mainly the results obtained in connection with the determination of the fuel value of said gases and oils. As the composition of these gases and oils is of considerable interest, the figures in the paper are reproduced in Tables I to III.

Helium and Associated Elements in Kansas Natural Gases was the title of a paper offered by C. W. SEIBEL. It is of interest to note that the gases from the Augusta fields carry as high as 1.97 per cent helium. This rare gas is the one occurring in the largest amounts, all the others being present in mere traces. Dr. R. B. MOORE suggested the use of such amounts of helium from a large gas supply for the filling of balloons if it were possible to extract it in an economic manner. Dr. H. P. CADY replied by stating that there would be no difficulty encountered in its extraction on a large scale.

Another interesting paper was that by E. P. FISHER, **Some Experiences in the Use of Oxy-Acetylene Welding in Long Distance Natural Gas Transportation.** Mr. Fisher gave a very interesting description of the process used in all of the lines of transportation for gases in the district. It differs from most other lines in that there are no joints or knees used throughout the system, all connections being made with the aid of the oxy-acetylene blow pipe. Many difficulties had to be overcome, such as, for instance, the time, condition and the type of laborer best suited for the work. It was decided to work in squads termed doubles, quads and eights. The doubles are those which weld two pipe lengths together, the quads weld two doubles and the eights weld two quads together. The most suitable type of labor was found to be the Bulgarian as, according to the author, some intelligence is required to do the welding satisfactorily. The paper was enlivened by a motion picture showing the various steps in manipulation.

Due to the length of time required for showing the pictures in the preceding paper, the last three papers had to be cut short. Dr. ROY CROSS presented a paper entitled **The Cracking of Petroleum in the Liquid State.** The writer stated that initially the temperature-pressure relation underlies the cracking of the petroleum. He demonstrated by curves the difference in the cracking of petroleums in the liquid and the gaseous state. Furthermore, the paper referred to the importance of the ratio of specific gravity to boiling point. If this ratio is low in a gasoline the latter is of a good quality.

WALTER F. RITTMAN'S paper, **One Billion Gallons of Synthetic Gasoline in 1918,** was read by GUSTAV EGLOFF. Five methods for cracking oils will be available for the production of gasoline. Cracking in the liquid state, cracking in the gaseous state, cracking in the presence of a catalytic agent, cracking by the use of oil and steam, and finally cracking by a combination of all the mentioned methods. The gasoline demand will rise proportionally to the number of automobiles used. One-fifth of all the gasoline produced in 1917 will be made by means of the cracking process. It is anticipated that 1,000,000,000 gal. of gasoline will be produced by one or the other of the cracking processes in 1918.

Dr. Egloff in his addenda to this paper showed the possibilities of producing benzene and trinitro-toluene by cracking and recracking. This is entirely feasible if the gas standard is changed from an illuminating to a heating standard. If this is done $25,000,000 may be saved annually in form of benzene, toluene and xylene.

The final paper of this session was rendered by HARRY H. HILL, **The Chemical work of the Petroleum Division of the Bureau of Mines.** Research is continually carried on by the department for the improvement of the products offered to the consumer. Petroleum, gasoline and other oil products are thus

investigated and analyzed as to their composition and properties. Investigations on the crackings obtained by the Rittman process are constantly conducted. Work on refining and establishing suitable standards is carried out by the bureau so as to prevent the market being flooded by unsuitable products.

Symposium on Zinc

The symposium on zinc covered the forenoon of the Thursday session, and was presided over by H. E. HOWE. The society is indebted to the endeavors of Dr. John Johnson, who was untiring in his work in preparing the symposium.

The first paper offered was a short one on **A New Method of Separating Zinc from Cadmium and the Determination of the Latter Iodometrically,** by ERIC J. ERICSON. Briefly it consists in crystallizing out the zinc from a zinc-ammonium sulphate solution, and then determining the cadmium by any of the well-known methods. The separation consists in crystallizing the zinc out as zinc sulphate or zinc-ammonium sulphate. It may be applied to the determination of cadmium in ore or in spelter (after removing and determining lead). In the latter case, although a small trace of cadmium is entrained in the crystals, only one crystallization is deemed necessary in view of the large sample taken. After removal of zinc, the cadmium may be determined by any of the usual methods. An iodometric method is outlined.

Determination of Cadmium in Brass by EDWARD SCHRAMM was the second paper offered. Small amounts of cadmium present in brass are exceedingly hard to determine. The method suggested by the author was first tried on known salt mixtures and then applied to commercial brasses. It consists of first partly freeing the nitric acid solution of copper by electrolysis, then precipitating out the rest of the copper, the tin and the lead by the ordinary method, then adding dilute sulphuric acid to the solution and getting the zinc and cadmium into the form of sulphates. The cadmium is then precipitated out by means of hydrogen bisulphide. The difference from the old method is in the precipitating out of the cadmium sulphide from a small volume of solution low in acidity. The cadmium sulphide after filtering is then converted into the sulphate by treating with sulphuric acid and reprecipitated as the sulphide by using ammonium polysulphide according to Noyes' method.

Mr. Schramm also read the third paper, the author of which was R. F. VON BICHOWSKY on **The Electrometric Determination of Zinc.** Three principal sources of error are encountered in the ordinary determination of zinc with potassium ferrocyanide. First oxidation of the ferrocyanide by any nitric acid, chlorine or bromine present; second, precipitation of other metals along with zinc; and third, uncertainty of the end point. To remove the first source of error, precautions such as the addition of SO_2 should be taken. To avoid the precipitation of other metals the rational procedure is to change the conditions of the ferrocyanide precipitation by carrying it out in solutions containing from 10 to 20 per cent HCl. In these solutions zinc ferrocyanide is only slightly soluble, but lead, manganese, iron, and copper ferrocyanides are very soluble.

Since the ordinary indicators cannot be used at this concentration of acid, an electrometric determination of the end point is adopted which is found to be quicker and more accurate than the older methods. This consists in noting the point at which there is a sharp change in potential of the solution against a platinum electrode. The apparatus is the same as that used in determining the end point of oxidation and reduction, reactions in the analysis of iron, vanadium, chromium, etc.

Experiments on a number of salt mixtures show that the end point is not affected by the amount of acid or neutral salts present within reasonable limits nor by the presence of iron, lead, manganese (up to 50 mg.) or by small amounts of copper and cadmium. The preliminary operations for the purification of the ore therefore lose their customary importance; comparative results show that the electrometric method is more rapid than the usual procedure.

Apparatus for the performance of the analysis were shown on a screen, as well as curves illustrating the success with which the analysis may be conducted in solutions containing 15 or less per cent of free hydrochloric acid. In the discussion which followed it was brought out that this method gave satisfactory results on ores carrying large amounts of copper, and that the method was just as rapid as the one used at the present time in zinc smelters.

In the absence of the author, E. H. BUCHANAN, the paper entitled, **The Occurrence of Germanium in Missouri and Wisconsin Blendes,** was ready by Dr. John Johnson. In this paper the author gave a brief history on germanium, and mentioned the discovery of this element in some blendes from Wisconsin and Missouri. He came to the conclusion that it may be generally accepted that 0.01 per cent of the amount of germanium found in smelter residues would be the amount of the element found in the original ore. These blendes might be used as a source for this rare element if some use for the metal could be found.

Dr. W. F. HILLEBRAND then showed a sample of metallic gallium and suggested this metal for the use of thermometers between 300 and 1000 C. in place of mercury, as its boiling point is 1700 C. The sample shown was liquid, resembling mercury, but having only about half its weight. It was kept under dilute sulphuric acid to prevent its adhering to the glass of the bottle. Dr. Hillebrand suggested that this adhering might be due to impurities similarly as with mercury.

Dr. JOHN JOHNSON then offered his own paper, **The Vapor Pressure of Zinc and Related Metals.** The paper was a compilation of all the available data on the vapor tension of metals, which were then summarized in the form of curves. As these curves are of considerable interest they are reproduced in Fig. 1. The scale of abscissas at the top gives the vapor tensions p, the scale at the bottom their logarithms. The scale of ordinates at the right gives degrees Centigrade, the scale at the left 1000 times the reciprocal values of the absolute temperature.

A rather lively discussion followed this paper, conducted by J. T. Baker and Dr. S. Fischer, Jr. The latter mentioned some work carried out by him under Dr. Joseph W. Richards at Lehigh University on the vapor tension of metals below their melting point. Formulæ were derived by which the vapor tension of any metal could be calculated for any temperature either in the liquid or the solid state. The plotting of the data indicated clearly the break in the vapor tension curve at the melting point of the metal in question.

The next paper on the program was entitled **The New Zinc Fields of Kansas-Oklahoma,** by P. HAYNES. The paper was illustrated by lantern slides. The present demand for zinc and its high value have caused a remarkable development in zinc mining and milling in the extreme southeastern part of Kansas and the adjoining northeastern part of Oklahoma. During the last six months many new towns and hundreds of mills have been built on the prairie lying to the southwest of the Galena-Joplin district. A visit to the new zinc fields

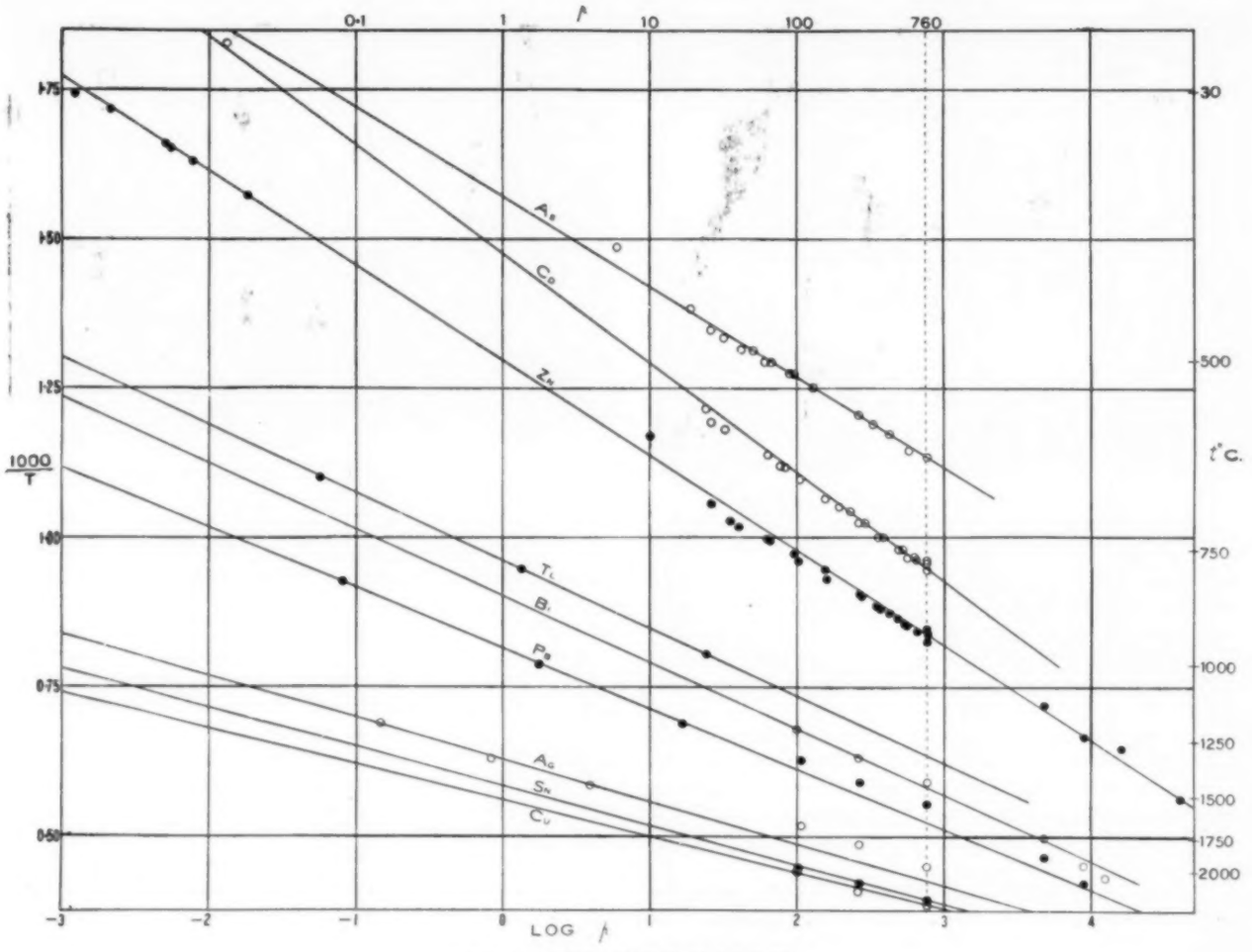


FIG. 1—VAPOR TENSION CURVES

south of Baxter Springs, Kan., and to Picher and Admiralty, Okla., shows the great strides in production which this district is making. Small drilling rigs dotting the prairie mark the advance guard prospecting to determine the value and extent of the ore bodies on each lease. Concentrating mills follow closely and give the appearance of a large city.

The ore minerals in this new district are chiefly sphalerite, with some galena and variable amounts of pyrite and marcasite. This ore is much richer than in the older Galena-Joplin district, and frequently contains over 20 per cent of sphalerite. The origin of the ores of this district is still somewhat in doubt, but the most recent researches by Siebenthal have led him to conclude that they have been produced from the disseminated sulphide minerals scattered through the Cambro-Ordovician limestones, by artesian waters transporting them in solution and ascending and depositing them in the open spaces of the cherty members (Grand Falls chert) of the Boone formations (Burlington or Mississippian limestone), which is the productive horizon in this region.

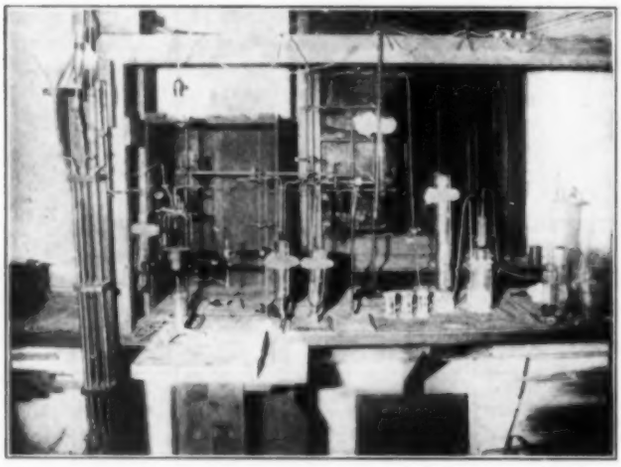
The paper by A. E. WELLS, **Results of Recent Investigations on Smelter Smoke Problems,** then followed. The dust and fume element it is claimed is not harmful to agriculture, but arsenic if present may harm live stock. On the other hand, it was indicated that amounts of arsenic present in smoke, sufficient to harm live stock, would be worth the saving by the smelter. Ways and means for the study of the effects of SO_2 on agriculture were then shown and explained. As a rule, wherever feasible the SO_2 should be converted into either sulphuric acid, liquid SO_2 or sulphur. This conversion naturally depended on the market demand of the locality for these products. Curves illustrating the concentration of SO_2 at different distances from the stack were shown. Also the effect of increased height of chimney and increased temperature of the stack gas on the SO_2 concentration were illustrated by curves. High stacks and high temperature, it is claimed, are the best means to eliminate the danger due to SO_2.

A paper by E. E. WATTS, on **The Hydrometallurgical and Electrolytic Treatment of Zinc Ore,** was read by title. It relates the writer's experimental work on the ore of the Sullivan mine at Kimberly, B. C. This work served to develop a process which involved sulphurous-acid leaching of the ore, and further experimental work developed the Watts process. By this process zinc oxide obtained by any suitable means is treated in specially constructed electrolytic tanks for the recovery of zinc. In conclusion the work done in the experimental plant of the Electro Zinc Company at Welland, Ont., is recorded.

Division of Industrial Chemistry and Chemical Engineering

The symposium on zinc actually was part of the elaborate program of the Division of Industrial Chemistry and Chemical Engineering. In the following we give abstracts of the other papers presented before this section.

The paper by O. R. SWEENEY and JAMES R. WITHROW dealt with the **chemical examination of industrial brines.** The value of chemical examination, from the manufacturer's standpoint, was discussed and a method was outlined. The errors resulting from improper sam-



EXPERIMENTAL LABORATORY FOR RARE GASES, UNIVERSITY OF KANSAS

COAL-TESTING LABORATORY, CHEMICAL BUILDING, UNIVERSITY OF KANSAS

pling were shown, and a suggestion for a standard method was given. The constituents which it is thought should be determined were given. A standard procedure for determining the density was described and the best temperature to use discussed. Suggestions for determining total solids were made; the procedures for silica, iron and aluminum were given. Simplifications of the usual methods for calcium and magnesium in mineral water were described, also the procedure for barium, strontium, sodium, potassium and sulphuric acid. A modification of the bromine determination was described.

A paper by FREDERICK DANNERTH dealth with the **industrial chemistry of chicle and chewing gum.** The author presents methods for the valuation of commercial block chicle by determining moisture, viscosity, resins, proteins and carbohydrates and mineral matter. Twenty problems relating to the chewing-gum industry were presented. The total exports of finished chewing gum amounted in 1916 to $574,400, equivalent to approximately 718,000 lb. This represents crude chicle equal to at least 179,000 lb. The amount of chicle imported, manufactured and consumed in the United States in 1916 was approximately 7,031,000 lb., equivalent to 28,124,000 lb. of chewing gum. The per capita consumption is roughly 3.5 lb. or 55 packages per annum. Researches are at present being carried out on the constituent elements of chicle—alpha chicl-alban; beta chicl-alban; gamma chicl-alban; chicl-fluavil, and chicl-gutta. These substances have been investigated by Tschirsch and later by Bosz and Cohen. The latter investigators have not entirely agreed with the results published by Tschirsch.

A paper by FREDERICK DANNERTH dealt with the cultural and Mechanical College) described **apparatus for determining the specific gravity of natural gas.** The apparatus is to be used according to the method proposed by Bunsen, which is based on the fact that the specific gravities of two gases bear approximately the same ratios to each other as do the squares of their rate of flow when passing through a very small opening.

The apparatus consists of a pipette or burette to which is sealed at right angles, just below the tip, a glass stop cock. To the tip of the burette another stop cock is sealed which is provided with a very small, practically invisible opening. The gas to be examined is admitted through the larger side opening and the time of escape is measured in the same manner.

The method is illustrated by the following example: The time required for the sample of gas to escape was 13.4 seconds and for the same quantity of air 11.8 seconds; these squared are equal to 150.4 and 129.9. As the specific gravity of natural gas is referred to air as unity, the specific gravity is obtained by dividing 129.9 by 179.5 = 0.723, the specific gravity of the gas.

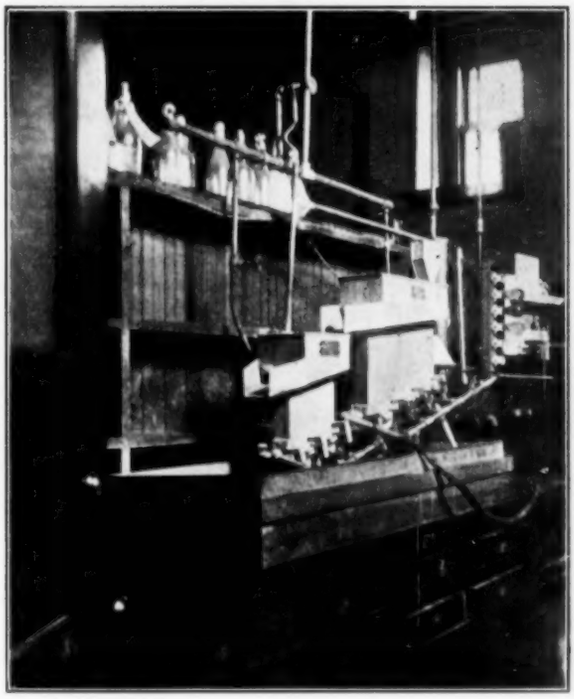
A paper by NIELS C. ORTVEA discussed comparative results from **experiments in the distillery with open and closed fermenters.** A closed iron fermenter of the latest type with a capacity of 4000 liters was brought from Germany in 1914 and a wooden open tub of the same capacity was constructed. Eleven experiments were made, fermenting simultaneously mash from the same batch in both vessels. The results obtained were in favor of the closed fermenter, viz., lower acidity in the finished beer, and increased yield, amounting to 1 per cent of spirit. The yields from the open fermenter corresponded to the average yields obtained in the ordinary normal runs of the distillery.

A paper by CHARLES S. REEVE and RICHARD H. LEWIS discussed the **effects of exposure of some fluid bitumens.** Exposure tests conducted for a period of one year show that certain types of petroleum harden materially while others are relatively little changed in their physical character, although all are materially changed in their composition as shown by the change in percentage of bitumen insoluble in naphtha and free and fixed carbon values. The relation between amounts volatilized upon heating for various periods in a laboratory oven at 163 deg. C. and the amounts lost upon atmospheric exposure were shown by tables, and relations between the characters of the residues obtained by the two methods of volatilization were given. As in previous work on the subject the changes which occur in bitumens upon exposure are notably greater than can be accounted for by mere loss of volatile constituents, and are due to chemical changes in the constitution of the bitumen itself.

There were two papers by GUSTAV EGLOFF. The first on benzene, toluene, and xylene from petroleum, is printed in full elsewhere in this journal. The second paper dealt with the **formation of benzene and toluene by the action of aluminium chloride on solvent naphtha.**

Solvent naphtha derived from the thermal decomposition of coal, having a specific gravity of 0.867/15.5 deg. C. and 93 per cent distilling between 135 deg. and 160 deg. C., with the dry point at 181 deg. C., was treated with anhydrous aluminium chloride. Five per cent by weight of $AlCl_3$ was added to 1 liter of solvent naphtha and distilled over in two hours from a Hempel flask until 78 per cent came over. The distillate was neutralized with caustic, washed and dried over calcium chloride. The distillate upon analysis gave on the basis

RESEARCH LABORATORY, UNIVERSITY OF KANSAS. FLOTATION WORK



CALLOW EXPERIMENTAL FLOTATION MACHINE, DIVISION OF STATE CHEMICAL RESEARCH, UNIVERSITY OF KANSAS

of solvent naphtha used 1.2 per cent of benzene and 13.9 per cent of toluene.

A paper by O. L. BARNEBEY discussed the **determination of available oxygen in oxidized manganese ores.** The oxalic acid method is the method in common use in America for the determination of available oxygen in oxidized manganese ores and hence is the basis for the evaluation of such ores for certain industrial purposes. This method gives inconsistent results, causing much difficulty in control work involving the use of pyrolusite and similar products. The method is shown to be highly empirical, the errors being produced by decomposition of the oxalic acid by the action of light in the presence of manganese salts. A modified ferrous sulphate method is accurate and is recommended for factory control work. The latter method gives results in close agreement with results obtained by Bunsen's distillation method and a new direct iodimetric method worked out by the author.

A paper by A. W. HIXSON and HAROLD E. HANDS discussed **some relations of the effect of over-heating to certain physical and chemical properties of asphalts.** The object of the research was: 1. Investigation of the extent to which an asphalt can be heated and still retain properties desirable for structural purposes. 2. To determine if "carbenes" are a result of overheating. 3. To determine the relation of carbene content to physical and chemical properties of asphalt. 4. To determine the value of the carbene specification for asphalts that are to be used for structural purposes.

An oil asphalic cement, a brick filler fluxed with an asphaltic oil residuum and a crude Trinidad asphalt were heated to various temperatures between 163 deg. C. and 250 deg. C. under uniform conditions. Physical and chemical analyses were made on the products of the various heatings.

The results show that heating asphalts above certain temperatures changes both the physical and chemical properties. The carbene content was not changed materially until the temperature of heating was above 200 deg. C. Above that temperature there was a decided increase in carbenes. The results seem to indicate that carbenes are the result of cracking paraffine and asphaltic hydrocarbons into naphthenes and unsaturated hydrocarbons. Moderate heating may so change the nature of the asphalts as to render them more soluble in carbon tetrachloride than in carbon disulphide. Overheating causes marked changes in natural and oil asphalts which render them unfit for many structural purposes. Two hundred and thirty-five deg. C. is probably the maximum temperature to which an asphalt may be heated without permanent injuries to its useful properties and for certain structural purposes they should not be heated above 200 deg. C. It is believed that the fixed carbon content when corrected to the original weight before heating offers a means of tracing the changes in the molecular structure of the hydrocarbons when they are subjected to the influence of heat.

There is a close relation between the carbene value and the physical and chemical properties of asphaltic materials. The carbene specification is important for asphaltic materials for construction purposes.

A paper by H. E. HOWE, of Arthur D. Little, Ltd., Montreal, Canada, discussed **the chemical industry of Canada.** Unfamiliarity with Canada, her industries, market and natural resources, has led many to consider that country a cold fringe on the North American continent, an excellent place for winter sports and fishing, but offering no opportunities for industry, especially chemical industry. Mr. Howe's paper outlined something of the chemical industry in Canada, with special reference to recent important developments and new processes which have been perfected under the stimulating influence of war conditions, but which will become important factors in the chemical business after the war. It also recounted something of the natural resources of Canada as indicating the raw materials upon which chemical processes and industries may eventually be based, and concluded with the statement of the steps that are being taken by private corporations, educational institutions and the Government to apply scientific and industrial research looking toward the more economic utilization of natural resources and the establishment of chemical industries to serve a population which will undoubtedly increase at an abnormal rate following the declaration of peace.

PLANT OF THE NATIONAL

A paper by D. A. Russell described the chemical laboratory of the Youngstown Sheet & Tube Company at Youngstown, Ohio, which provides for the departments of metallurgy, chemistry and inspection. The construction of the building, arrangement of rooms and equipment were described, attention being called to special features.

A paper by H. W. Gillett and E. L. Mack on **ferro-uranium** first reviewed the information so far available and rather contradictory on the use of uranium steels as tool steel and ordnance steel on the production of ferro-uranium by former experimenters. The authors then described experiments of their own in which they used uranium oxide produced by the National Radium Institute. It was mainly UO_2, with some U_2O_3. The main results of the authors' experiments may be summed up as follows:

By using a pure UO_2, a low-ash coke, and a pure iron as raw materials, with CaF_2 as slag former, and using a tilting electric direct-arc type furnace with water-cooled magnesite hearth and sides, it should be possible to produce commercially, without a second refining operation, ferro-uranium of any desired U content, say 40 to 70 per cent, with carbon averaging below 2.0 per cent, silicon below 0.75 per cent, vanadium below 0.5 per cent, and with aluminium, sulphur, phosphorus and manganese all so low as to be negligible.

If experiments with such a ferro show that uranium steels high in uranium are not valuable, but that a little uranium is useful, and if the amount required is so low that the carbon introduced by a high-carbon ferro is harmless, then the furnace might have an uncooled carbon hearth, and the ferros would contain 4 to 5 per cent carbon.

If uranium is found useful only as a deoxidizer or scavenger of oxygen and nitrogen, aluminium would not be harmful and might be advantageous, and the slag might be found wholly or in part of Al_2O_3.

There were also two papers by J. P. Schroeder, one on the **availability of nitrogen in fertilizers** (a new method based on the nitrogen rendered water-soluble by incubation with a fertile soil), and the other paper on the **fertilizer value of city wastes**, and on garbage tankage, its composition, the availability of its nitrogen, and its use as fertilizer.

The author had prepared complete analyses of twenty samples of garbage tankage representing all the larger garbage reduction works in operation in this country. After removal of the oil, which is usually about 12 per cent, there is a remainder of an average of 3.3 per cent ammonia, 7.84 per cent bone phosphate, and 0.8 per cent potash. The profitable use of this by all cities of 50,000 and more inhabitants was discussed by the author with the methods available for this purpose.

Division of Physical and Inorganic Chemistry

H. P. Talbot was chairman of this division. Twenty-two papers were either read in abstract or read by title. The list of the papers is as follows:

F. P. Siebel. Negative and Positive Specific Heat of Saturated Vapor.

E. W. Washburn and Karl A. Clark. The Dependence of Ion Conductance Upon the Viscosity of the Medium. (Lantern.)

J. H. Walton and Albert Brann. The Effect of Colloids on the Velocity of Crystallization of Water. (Lantern.)

B. S. Hopkins and Edward Wichers. The Separation of Erbium from Ytrium.

Clarence W. Balke and Edward Wichers. A Study of the Ratio Er_2O_3:2ErCl$_3$.

L. I. Shaw and B. H. Ball. Thermal Studies of Some Members of the System PbO-SiO_2.

L. I. Shaw. Preliminary Studies on the Change of Conductivity with Time in the System: Methyl Alcohol-Iodine-Water.

James Brown. Use of "Cupferon" (Ammonium Nitrosophenylhydroxylamine) in the Analysis of Zirconium Minerals.

S. C. Lind, C. F. Wittemore and J. E. Underwood. The Solubility of Pure Radium Sulfate.

S. C. Lind. Studies in Pseudo-Isotropy. I.

Harry N. Holmes. Silicic Acid Gels.

Harry N. Holmes. Rhythmic Banding.

Harry N. Holmes. Peptization and Gel Formation of Ferric Arsenate and Phosphate.

O. L. Barneby and Bishop. Differential Iodimetry. IV. Determination of Manganese Dioxide in the Presence of Ferric Iron.

O. L. Barneby. Reactions in Non-aqueous Solvents. III. Some New Double Univalent Halides.

F. H. MacDougall. Density of the Transition Layer Between Liquid and Vapor. (By title.)

F. H. MacDougall. Dieterici Equation of State. (By title.)

Jean Piccard. Colors of Second Order.

Marks Neidle. Precipitation, Stability and Constitution of Hydrous Ferric Oxide Sols. (By title.)

ZINC CO., NEAR KANSAS CITY, KANSAS

MARKS NEIDLE and JACOB BARAB. Oxidation-Reduction Reactions Without the Addition of Acid. IV. Ferrous Chloride-Potassium Dichromate and Ferrous Chloride-Hydrogen Peroxide. (By title.)

MARKS NEIDLE and JACOB BARAB. Studies in Dialysis. III. Mixtures of the Chlorides of Ferric Iron, Aluminium and Chromium. (By title.)

WILLIAM D. HARKINS. Emulsification as Related to the Orientation of Molecules in the Surfaces of Liquids.

Unfortunately Mr. Siebel was not present and his paper was not read.

The paper by E. W. WASHBURN and KARL A. CLARK was of interest in so far that it gave a method for calculating h, the power to which the relative viscosity n has to be raised in the equation.

$$d = \frac{L}{L_o} \times n$$

where L signifies the conductance of one equivalent of salt, L_o the equivalent conductance in the particular solution, d the degree of ionization and n and h the already designated quantities; h is measured by taking the conductivity measurements of the materials in question in an aqueous solution at various concentrations. Curves are then plotted from the equation:

$$\log L_o = L_{ow} + h \log f$$

where L_o is the desired conductance, L_{ow} the conductance of water and f the fluidity of the solution. Many curves were shown during the course of the paper.

J. H. Walton and Albert Brann were absent, their paper being read by title only.

The paper by B. S. HOPKINS and EDWARD WICHERS on the separation of erbium and ytrium is essentially based on the separation of these elements by fractional precipitation of the cobalticyanide compounds.

CLARENCE B. BALKE and EDWARD WICHERS then presented their paper on a study of the ratio Er_2O_3:2ErCl$_3$. This paper is the outcome of some investigations in connection with the determination of the atomic weight of erbium. The authors found this ratio to vary between 168.54 and 168.84. These values are slightly higher than the value accepted for the atomic weight of erbium, which is 167.7. The reason for this difference in atomic weights has not been explained.

L. I. SHAW and B. H. BALL in their preliminary paper on thermal studies of some members of the system PbO-SiO_2 found that the curve indicated three and possibly four maxima. The first has the formula $PbO \cdot SiO_2$, the second $2PbO \cdot SiO_2$, the third $2PbO \cdot 5SiO_2$ and the fourth $PbO \cdot 4SiO_2$. They also found that the transition point for SiO_2 was at 540 to 580 deg. C. Two eutectics with a possible third were also indicated by the curve.

Two very interesting papers were presented by C. S. LIND, C. F. WITTEMORE and J. E. UNDERWOOD. The first of the two papers was written by the gentlemen mentioned, while the second was Dr. Lind's own work. Abstracts of the papers are as follows:

The paper of the three joint authors discussed the solubility of pure radium sulphate. The solubility of $RaSO_4$ in water and other solutions is of practical interest since all processes for the recovery of radium from its ores involve, at some stage, the precipitation of radium together with barium as sulphate. On the theoretical side, the fact that the partial precipitation from solution of a mixture of radium and barium as sulphate, leads to no change in their relative concentrations, reminds one of the action of isotopic elements, and suggests identity of solubility of the two sulphates. The solubility of $BaSO_4$ at 25° has been shown by Hulett to be 2.39 to 10^{-4} gram per c.c. However, a comparison of the solubilities of $CaSO_4$, $SrSO_4$ and $BaSO_4$ would lead one to expect $RaSO_4$ to have a solubility of the order of 1×10^{-3} gram per c.c. On the other hand, in practice it is possible in precipitating $RaSO_4$ from a mixture in which the Ra:Ba(SO_4) ratio is 1 to 1,000,000 to reduce the concentration of $RaSO_4$ to the order of 10^{-12} gram per c.c.

A direct determination of the solubility has been made by the authors using 100 per cent material resulting from the co-operative work of the U. S. Bureau of Mines and the National Radium Institute. The emanation method was employed. The equilibrium was reached from both sides by dissolving $RaSO_4$ in H_2O and in 0.01N, 0.1N and 1N, H_2SO_4 solutions respectively, and by precipitating radium in H_2SO_4 solutions of the same concentrations. The solubilities in water and in H_2SO_4 up to 1N concentration are nearly identical, about 2×10^{-6} gram of $RaSO_4$ per c.c. This result shows that the solubility of $RaSO_4$ predicted by comparison with those of the other members of the periodic group is the true one, more than 100 times less than that of $RaSO_4$. Excess of H_2SO_4 seems to have no repressive effect on the solubility concentration from zero to 1 normal. The "effective" solubility of $RaSO_4$ of the order of 10^{-12} gram $RaSO_4$ per c.c. is to be explained by the inseparability of Ra and Ba by precipitation, the $BaSO_4$ in solution being reduced by excess of re-

agent to its own solubility value, and radium remains in solution in the same proportion to barium as in the original solution before precipitation.

Studies in Pseudo-Isotropy" was the title of Dr. Lind's paper. Experiments of the author and others have shown that when radium and barium are partially precipitated from a solution containing a mixture of the two, no change in relative concentration takes place. This is true for sulphate, oxolate, carbonate, and perhaps all other difficultly soluble salts, and bears an exact analogy to the inseparability of the isotopic elements. The fact that radium and barium are only pseudo-isotopic, however, is shown from the great divergence of their atomic numbers, and their ready separation by recrystallization of the chlorides or bromides. It has been shown in the preceding paper that the assumption of identical solubility of $RaSO_4$ and $BaSO_4$ in analogy to their pseudo-isotopic action in precipitation reactions is far from the truth. Conversely, this must raise the question from the purely experimental side as to the truth of the assumption generally made of identical solubility of true isotopes.

The high degree of *inseparability* of radium and barium by reactions of precipitation (and of solution, one may add) together with their *ease of separation* by crystallization, constitute the phenomenon which the author desires to term, at least, provisionally, *pseudo-isotopy*. The combination of these two opposite effects is a most fortunate circumstance in the recovery of radium in a state of purity. Without the isotopic effect there would be no possibility of recovering radium. If it were a true isotopism there would be no possibility of separating radium from barium. The purpose of the succeeding parts of this study will be to investigate the extent, degree of exactness, state of equilibrium, and other problems relating to the pseudo-isotopy of radium and barium, as well as to extend the study to other elements. The applicability of the present theory of adsorption to the phenomenon appears especially open to investigation.

Abstracts of the other papers while of interest must be omitted, due to the fact that most of the authors were absent, and also because the subject matter is not directly of importance to the readers of this journal.

The Smoker and Banquet

The smoker was held on the evening of April 11 at the Hotel Muehlebach. The gathering was entertained by some local as well as outside talent. Music, short acts, recitations and a wireless station did much to make the evening hilarious. Especially appreciated were the curt messages over the wireless, which did much to amuse the crowd at the expense of some of the members present. As a finale to this enjoyable evening, a luncheon was served which undoubtedly added to the zest of the company.

Thursday evening a subscription banquet was in session. The toastmaster of the evening was Dr. CHAS. H. HERTY. Due to the present crisis, as would be expected, most of the speakers made addresses on patriotic subjects. So did Dr. J. STIEGLITZ, the president of the society. Dr. W. L. BURDICK'S topic was patriotism, true patriotism, not mere words. Dr. E. W. WASHBURN talked on what the English chemist did for England on short notice, and mentioned that the same should be done here. Mr. J. H. ATWOOD, a banker of Kansas City, then spoke at length on what should be done at the present time. He emphasized the fact that real faith in what one is doing will of necessity result in success. Mr. ELWOOD HENDRICK'S speech on publicity in chemical matters was concise and to the point. The general need of chemistry should be realized by the public at large. In bringing chemical matters before the public Mr. Hendrick suggests that chemical terms be modified and simplified so that the ordinary man will be able to understand something of chemistry.

Undoubtedly every one present was impressed with the short and modest speech made by Col. KEALY. For there was a man who, having sacrificed his lucrative business position, had given his personal services to the country. No one felt like asking him after his speech what he had done personally to aid the country. The colonel evidently does not believe very strongly in the much quoted maxim of "letting George do it." The man of action is always admired at a time when action is so sorely needed.

The ladies present were very cordially entertained. On Wednesday afternoon a tea was given at the Muehlebach which was followed by a theater party in the evening. Thursday was spent in taking an automobile drive.

Visits and Excursions

So many interesting trips were offered that it was impossible to take them all. Thursday afternoon the guests had the pleasure of becoming familiar with the beauties of Kansas City itself. An automobile trip through the most interesting sections was taken by all at 4.30 in the afternoon. On Friday afternoon trips to the National Zinc Company, to the soap and glycerine manufacturing plant of Peet Brothers, to the Southwest Milling Company, to the Armour Packing Plant and to the Standard Oil Refinery at Sugar Creek were made, and on Saturday to the University of Kansas, the Monarch Vinegar Works, the Kansas City Galvanizing Company and Heim's Brewery.

THE NATIONAL ZINC COMPANY

This company's plant is situated about 8 miles outside of Kansas City, Mo., on the Kansas side, and covers an area of about 40 acres. It is a roaster and not a smelter, handling about 150 tons of Butte, Mont., zinc flotation concentrate per day. The concentrates are first dried and then roasted in two Hegeler furnaces and ten modified De Spirlet furnaces, the Hegeler furnaces handling 50 tons each and the ten kilns 50 more. The plant also produces 150 tons sulphuric acid per 66 deg. Bé., which finds a ready market in the oil refineries. Furthermore, muriatic and nitric acid are produced besides salt cake, Glauber salt, nearly chemically pure zinc sulphate and copperas. A flow-sheet of the plant is given in Fig. 2.

THE UNIVERSITY OF KANSAS

Forty miles from Kansas City lies the town of Lawrence, Kan. A hill in this flourishing town overlooking a vast expanse of the fertile Kansas plains is occupied by the Kansas State University. The many buildings of the institution are constructed of rock quarried from the locality. They present a stately and beautiful appearance. The university accommodates 3000 students, 1200 of which are young women.

Not the least of the university's attractions is the Dyche Museum, founded by the man after whom the collection is named. It occupies a building of its own. The founder endeavored to collect specimens of all American animal life and to arrange them according to their natural surroundings. It is an inspiring sight on entering the portals of the building to behold the wonderful animal groups. They would seem to be alive.

The Chemistry Building also harbors metallurgy. A series of photographs show the building and some of the laboratories and lecture rooms. Incessant work is being conducted by the able staff both along chemical

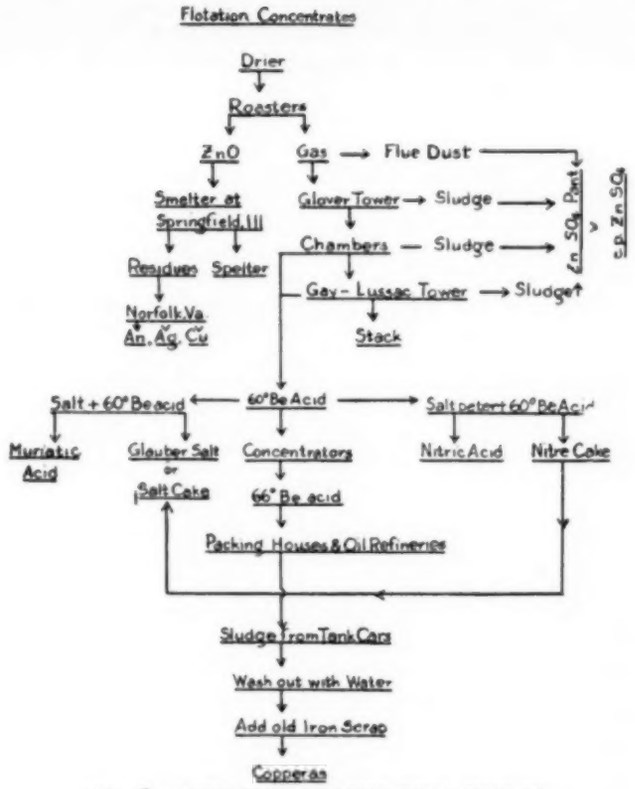


FIG. 2—FLOW SHEET OF NATIONAL ZINC CO.

and metallurgical lines, the department being very well equipped to undertake such work in all fields. An interesting feature is the apparatus for the production of liquid air and rare gases. The department furnishes liquid air and rare gases to any institution or industrial plant which wishes to carry on research work along that line. The very valuable work on the flotation process carried out here under the direction of Prof. W. A. Whitaker is well known to our readers from two articles by Professor Whitaker and his co-workers in our Vol. XIV, page 33, and Vol. XV, page 131.

Upon arriving at Lawrence the many strangers in the Chemical Society party were surprised at the largeness of the town. The city of Lawrence has a population of approximately 14,000 people, who seem to be doing things. The Bowersock Paper Mills and the Zephir Flour Mill were first inspected by the visitors. At the paper mill they produce corrugated paper box wood. The box material is put up in such shape that the buyer has nothing further to do but fold it. The hugeness of the machinery required at this plant is impressive.

Part of the morning was spent at the Haskell Indian School, where the student battalion paraded in honor of the American Chemical Society. Dinner was served at the University Club. The afternoon was spent in inspecting the buildings of the university, by riding around town, while at the local Country Club tea was served.

None of those present will forget the hospitality, not only of the people of Lawrence but especially of the faculty of the University of Kansas.

EXHIBITS

As mentioned in the earlier part of this report, it is to be regretted that so few local exhibits were on hand, those shown were mostly from outside of the Kansas City zone, but were decidedly interesting. The Brown Instrument Company of Philadelphia showed some of their temperature-reading devices. Schaar & Co. of Chicago exhibited some of their imported Japanese laboratory ware and instruments. A. Daigger & Co., also of Chicago, demonstrated Hoyt's penetrometer, a new instrument used in testing asphalts. H. Reeve Angel & Co. of New York City showed the Whatman filter papers, and finally the Herold China & Pottery Company of Golden, Col., had a display of some of their glazed and unglazed laboratory wares.

On Saturday, April 14, this patriotic meeting came to a close. To the Kansas members who so faithfully endeavored to make this meeting agreeable to their guests the society owes sincere gratitude, and all who attended the meeting went home with a feeling of earnest respect for the brilliant possibilities of the great Middle West.

The following is a complete alphabetical list of those who registered at the Kansas City meeting:

Samuel Adler, Kansas City, Kans.; C. T. Allcutt, Kansas City, Mo.; Mr. and Mrs. H. C. Allen, Lawrence, Kans.; C. A. Altman, Kansas City, Kans.; H. M. Andrews, Kansas City, Mo.; Fred'k C. Atkinson, Indianapolis, Ind.; Warren H. Atwood, Ayer, Mass.; J. H. Attwood, Kansas City, Mo.; N. T. Bacon, Teacedale, R. I.; J. R. Bailey, Austin, Tex.; E. H. S. Bailey, Lawrence, Kans.; Mr. and Mrs. J. T. Baker, Phillipsburg, N. J.; O. L. Bamebey, Madison, Wis.; R. C. Bardwell, St. Louis, Mo.; Mr. and Mrs. Wm. M. Barr, Omaha, Neb.; Geo. C. Bartelk, Jr., Collinsville, Ill.; Edward Bartow, Urbana, Ill.; N. R. Beagle, Peoria, Ill.; Robt. S. Beard, City Hall, K. C., Mo.; A. T. Beckley, Lawrence, Kans.; H. V. Berg, Newport, Ill.; Emily Berger, Halstead, Kans.; O. W. Berndt, Chicago, Ill.; W. D. Bigelow, Washington, D. C.; F. O. Blaylock, De Soto, Kans.; Mr. and Mrs. H. E. Bonnette, Bartlesville, Okla.; R. R. Boehmer, Kansas City, Mo.; Geo. Borrowman, Lincoln, Neb.; A. C. Boylston, St. Louis, Mo.; A. J. Boynton, Lawrence, Kans.; Wm. Brady, Chicago, Ill.; J. W. Brandel, Berwyn, Ill.; Roy I. Brewster, Lawrence, Kans.; Frank P. Brock, Chicago, Ill.; Jas. Brown, Indianapolis, Ind.; H. W. Brubaker, Manhattan, Kans.; F. W. Bruckmiller, Lawrence, Kans.; T. J. Bryan, Chicago, Ill.; Ralph Buffington, Lawrence, Kans.; Edmund Burke, Bozeman, Mont.; L. S. Bushnell, Kansas City; C. W. Burchard, Manhattan, Kans.; H. V. Cadwell, Chicago, Ill.; H. P. Cady, Lawrence, Kans.; J. H. Calbeck, Blackwell, Okla.; S. Calvert, Columbia, Mo.; Fred. W. Campbell, Kansas City, Mo.; W. L. Carlyle, Stillwater, Okla.; Harry A. Carpenter, Rochester, N. Y.; Mary Carpenter, Lawrence, Kans.; H. P. Carter, Kansas City, Mo.; Edward H. Carus, La Salle, Ill.; Henry J. Cary-Curr, Chicago, Ill.; P. R. Chamberlain, Dewey, Okla.; W. McClung Childs, Kansas City, Kans.; E. H. Clark, Kansas City, Mo.; F. E. Clark, Morgantown, W. Va.; John D. Clark, Albuquerque, N. M.; Lee E. Clark, Winchester, Kans.; Rowland J. Clark, Lawrence, Kans.; P. W. Classen, Lawrence, Kans.; G. H. Clay, Kansas City, Mo.; A. M. Clover, Detroit, Mich.; W. M. Cobleigh, Bozeman, Mont.; Leon A. Congdon, Topeka, Kans.; W. F. Coover, Ames, Iowa; Marshall Cram, Brunswick, Maine; E. J. Crane, Columbia, Ohio; Walter D. Crebs, Dayton, Ohio; Roy Cross, Kansas City, Mo.; Walter Cross, Kansas City, Mo.; S. J. Crumbine, Topeka, Kans.; Chas. S. Curtis, Kansas City, Mo.; F. B. Dains, Lawrence, Kans.; Benton Dales, Lincoln, Neb.; N. N. Dalton, Kansas City, Mo.; J. H. Davidson, Pittsburg, Kans.; Arthur L. Davis, Liberty, Mo.; G. W. Davis, Kansas City; Frank Louis Debenkdaer, Topeka, Kans.; A. W. Dox, Ames, Iowa; Col. Dravo, Kansas City; Frank H. Driggs, Baldwin, Kans.; Gaston Du Bois, St. Louis, Mo.; F. L. Dunlap, Chicago, Ill.; R. B. Dunlevy, Winfield, Kans.; Harold M. Eastman, Denver, Colo.; Gustav Egloff, Yonkers, N. Y.; John B. Ekeley, Boulder, Colo.; Frank R. Eldred, Indianapolis, Ind.; Frank W. Emmons, Minneapolis, Minn.; W. D. Engle, Denver, Colo.; Clarence Estes, Bartlesville, Okla.; A. W. Estabrook, Kansas City, Mo.; Wm. Lloyd Evans, Columbus, Ohio; Mr. and Mrs. Henry O. Eyssell, Kansas City, Mo.; Paul V. Faragher, Lawrence, Kans.; Frank Farley, Lawrence, Kans.; Frederic Fenger, Chicago, Ill.; Royal Fillmore, Kansas City; Siegfried Fischer, Jr., Golden, Colo.; Anthony P. Fonda, Independence, Mo.; Chester C. Fowler, Ames, Iowa; Barber B. Francis, Kansas City, Mo.; Chas. K. Francis, Stillwater, Okla.; Geo. B. Frankforter, Minneapolis, Minn.; Francis C. Frary, Niagara Falls, N. Y.; D. K. French, Chicago, Ill.; Thos. B. Freos, New York City; W. S. Frisbie, Lincoln, Neb.; Robt. R. Fulton; C. M. Fulton, Kansas City, Mo.; H. D. Gibbs, Washington, D. C.; S. W. Gibson, Wakeeney, Kans.; G. C. Glynn, Kansas City, Kans.; John P. Goheen, Philadelphia, Pa.; Howard T. Graber, Detroit, Mich.; Mr. and Mrs. G. W. Gray, Eldorado, Kans.; A. B. Greene, St. Joseph, Mo.; Chas. W. Greene, Columbia, Mo.; H. W. Greider, Topeka, Kans.; H. S. Grindley, Urbana, Ill.; A. A. Groening, Lawrence, Kans.; O. S. Grouer, Ottawa, Kans.; C. F. Gustafson, Kansas City; F. C. Gutsche, Manhattan, Kans.; J. Sam Guy, Fayetteville, Ark.; L. D. Haigh, Columbia, Mo.; Chas. J. Haines, Sapulpa, Okla.; H. L. Hale, Neodesha, Kans.; Mr. and Mrs. Harrison Hale, Springfield, Mo.; L. B. Hall, Rochester, N. Y.; Rolla N. Harger, Lawrence, Kans.; C. D. Harlow, Kansas City; L. D. Havenhill, Lawrence, Kans.; W. D. Hawley, Coldwater, Mich.; Winthrop P. Haynes, Lawrence, Kans.; W. P. Heath, Atlanta, Ga.; C. L. Henderson, Kansas City; Ellwood Hendrick, New York; O. B. Heppner, Springfield, Mo.; Chas. M. Heron, El Tigre, Sonora, Mexico; Tom Herrington, Denver, Colo.; Chas. Hermann, Kansas City, Mo.; Chas. H. Herty, New York City; D. M. Hetler, Lawrence, Kans.; Harry H. Hill, Pittsburgh, Pa.; W. F. Hillebrand, Washington, D. C.; Rudolph Hirsch, Kansas City, Mo.; E. M. Hitzeman, Kansas City, Kans.; A. W. Hixon, Iowa City, Ia.; Robt. Hochstetter, Cincinnati, Ohio; Albert G. Hogan, Manhattan, Kans.; Jas. H. Holden, Lawrence, Kans.; W. W. Holland, Alton, Ill.; Harry N. Holmes, Oberlin, Ohio; Major Holmes, Cleveland, Ohio; E. E. Howard, Kansas City; Locy C. Howe, Kansas City, Mo.; H. E. Howe, Montreal; C. S. Hudson, Washington, D. C.; E. Don Hughes, Lawrence, Kans.; J. S. Hughes, Manhattan, Kans.; L. C. Hughes, Hutchinson, Kans.; Otto W. Huhn, Kansas City, Mo.; A. H. Huisken, Lawrence, Kans.; W. H. Hunter, Minneapolis; Wm. K. Ilhardt, St. Louis, Mo.; John C. Ingram, Rolla, Mo.; Earl F. Insley; Roy Irwin, Lawrence, Kans.; W. M. Janney, Lawrence, Kans.; Sam'l C. Johnson, Eureka, Kans.; Carl Johnson, Topeka, Kans.; John Johnson, St. Louis, Mo.; Ernest E Jones, LaSalle, Ill.; Lander W. Jones, Cincinnati,

Ohio; Olivet Kamm, Urbana, Ill.; S. E. Kelsey, Kansas City, Mo.; Cleo H. Kidwell, Lawrence, Kans.; H. H. King, Manhattan, Kans.; E. B. Kneer, M.D., Kansas City, Mo.; S. B. Kuzirian, Ames, Ia.; L. Krischbraum, Chicago, Ill.; A. R. Lamb, Ames, Ia.; S. C. Langdon, Seattle, Wash.; H. W. Larson, Chicago, Ill.; Wendell M. Latimer, Lawrence, Kans.; Lloyd L. Lawless, Kansas City, Mo.; A. F. Layman, Kansas City, Mo.; J. W. Lazear, Kansas City, Mo.; E. C. Lefevre, Lawrence, Kans.; Mary F. Leach, Oxford, Ohio; H. L. Lentz, Lawrence, Kans.; W. H. Leverett, Kansas City, Mo.; H. A. Levey, Chicago, Ill.; W. Lee Lewis, Evanston, Ill.; S. C. Lind, Golden, Colo.; Mrs. T. C. Lind, Kansas City, Mo.; C. T. Long, Cincinnati, Ohio; Walter S. Long, Lawrence, Kans.; B. F. Lovelace, Baltimore, Md.; Wilson H. Low, South Omaha, Nebr.; Arthur Lowenstein, Chicago, Ill.; A. C. Lyon, Kansas City, Mo.; O. L. Maag, Lawrence, Kans.; E. Mallinckrodt, Jr., St. Louis, Mo.; Jos. W. Malcomnson, Kansas City, Mo.; L. B. Mangum, Kansas City, Kans.; Chas. A. Mann, Ames, Ia.; J. W. Marden, Columbia, Mo.; G. F. Mason, Pittsburgh, Pa.; S. A. Matthews, Lawrence, Kans.; Mary E. Mayer, Chicago, Ill.; Arthur McClain, Webb City, Mo.; C. R. McKee, Milwaukee, Wis.; Ralph H. McKee, Ridgefield Park, N. J.; L. H. McLaren, Lawrence, Kans.; LeRoy McMaster, St. Louis, Mo.; F. Lee Mickle, Urbana, Ill.; Reginald Miller, Merriam, Kans.; R. U. Mitchell, Wichita, Kans.; Mr. and Mrs. R. B. Moore, Golden, Colo.; Wm. C. Moore, Cleveland, Ohio; C. B. Morey, Buffalo, N. Y.; Clarence A. Morrow, University Place, Nebr.; A. V. H. Mory, Chicago, Ill.; C. Robert Moulton, Columbia, Mo.; F. W. Muncie, Urbana, Ill.; C. F. Nelson, Chicago, Ill.; H. A. Nelson, Lawrence, Kans.; Ralph C. Neuston, East Lansing, Mich.; P. J. Newman, Manhattan, Kans.; H. T. Nixon, Kansas City, Mo.; Niels C. Ortved, Walkerville, Ontario; O. R. Overman, Huron, S. D.; F. T. Owen, Emporia, Kans.; Leroy S. Palmer, Columbia, Mo.; Arthur M. Pardee, Tarkio, Mo.; H. G. Parker, Liberty, Mo.; I. P. Parkhurst, Lawrence, Kans.; Chas. L. Parsons, Washington, D. C.; Bart Park; Atchison, Kans.; E. J. Patterson, Kansas City, Kans.; J. N. Pearce, Iowa City, Ia.; E. M. Perdue, Kansas City, Mo.; Geo. O. Peterson, Chicago, Ill.; Isaac K. Phelps, Washington, D. C.; Harley M. Plum, Lincoln, Nebr.; F. B. Porter, Ft. Worth, Tex.; R. S. Potter, Ames, Ia.; Paul Powell, Baldwin, Kans.; J. T. Power, Wilmington, Del.; B. S. Proper, New York; W. P. Putman, Detroit, Mich.; W. E. Pyke, Yates Center, Kans.; Chas. F. Quaintance, Golden, Colo.; J. B. Rather, Fayetteville, Ark.; D. L. Randall, Baldwin, Kans.; Chas. Rascher, Chicago, Ill.; O. T. Rees, Topeka, Kans.; W. J. Reese, Kansas City; H. W. Rhodehamel, Indianapolis, Ind.; W. D. Richardson, Chicago, Ill.; H. H. Richardson, Lawrence, Kans.; Donald Riley, Chicago, Ill.; Mr. and Mrs. E. G. Rippel, Buffalo, N. Y.; G. W. Roark, Jr., Ames, Iowa; Martin V. Robbins, Kansas City, Kans.; J. D. Robertson, St. Louis, Mo.; J. M. Roberts, Chicago, Ill.; E. W. Rockwood, Iowa City, Iowa; C. Y. Roop, Berkeley, Cal.; Harry L. Roscoe, Kansas City, Mo.; Mary E. Rose, Lawrence, Kans.; Chas. F. Roth, New York City; Paul Rudnick, Chicago, Ill.; Herbert W. Rumsfeld, Kansas City, Mo.; D. A. Russell, Youngstown, Ohio; Mr. and Mrs. J. C. Russel, McPherson, Kans.; A. R. Sasse, Kansas City, Mo.; Mr. and Mrs. L. E. Sayre, Lawrence, Kans.; A. E. Schaar, Chicago, Ill.; Edward Schramm, St. Louis, Mo.; J. P. Schroeder, Washington, D. C.; A. M. Schroepper, Wamego, Kans.; Robert Carl Schroth, Jr.; F. W. Schulenberger, New York City; Herman Schlundt, Columbia, Mo.; Robt. Glardon Scott, Columbia, Mo.; Geo. W. Sears, Urbana, Ill.; H. A. Senter, Omaha, Neb.; Louis Shannon, Columbia, Mo.; L. I. Shaw, Evanston, Ill.; E. D. Sherrick, Kansas City, Mo.; W. W. Skinner, Washington, D. C.; F. H. Sibley, Lawrence, Kans.; Herbert G. Sidebottom, New York City; C. W. Siebel, Lawrence, Kans.; Mrs. H. T. Sill; Herbert F. Sill, Columbia, Mo.; J. Claude Simpkins, Missoula, Mont.; F. F. Skillman, Kansas City, Mo.; Ernest R. Smith, Kansas City, Mo.; Alexander Smith, Columbia, New York City; Mr. and Mrs. W. Bradford Smith, Kansas City, Mo.; C. H. Sonntag, Cape Girardeau, Mo.; C. H. Spaulding, Kansas City; Jack Spencer, Junction City, Kans.; Mr. and Mrs. C. C. Spilman, Kansas City, Kans.; Elizabeth C. Sprague, Lawrence, Kans.; Louise Stanley, Columbia, Mo.; E. L. Stateler, Lawrence, Kans.; Julius Stieglitz, Chicago, Ill.; O. O. Stoland, Lawrence, Kans.; Geo. W. Stratton, Lawrence, Kans.; Mr. and Mrs. Frank Strong, Lawrence, Kans.; Mrs. Geo. S. Stroud; Robert E. Swain, Berkeley, Cal.; J. N. Swan, University, Miss.; C. O. Swanson, Manhattan, Kans.; Avis Talcott, Lawrence, Kans.; Mr. and Mrs. Frank O. Taylor, Detroit, Mich.; A. D. Thorburn, Indianapolis, Ind.; W. E. Threen, Columbia, Mo.; R. W. Titus, Emporia, Kans.; E. A. Todd, Lawrence, Kans.; P. F. Throwbridge, Columbia, Mo.; Fred W. Upson, Lincoln, Nebr.; C. A. A. Utt, Manhattan, Kans.; James G. Vail, Chester, Pa.; H. L. Van Velzer, Ft. Scott, Kans.; Lulu A. Vickery, Kansas City, Mo.; J. J. Vollertsen, Chicago, Ill.; Jack Waggoner, Lawrence, Kans.; Harold Wakefield, Winfield, Kans.; W. J. Waite, Kansas City, Mo.; Albert H. Walt, Kansas City; Porter M. Waldron, Columbia, Mo.; F. C. Walters, Jr.; H. E. Walton, Kansas City, Mo.; Miss Nell Ward, Lexington, Mo.; Jas. T. Ware, Independence, Mo.; E. W. Washburn, Urbana, Ill.; G. N. Watson, Lawrence, Kans.; Richard O. Webster, Chicago, Ill.; O. M. Weigle, Fulton, Mo.; J. E. Welin, Lindsborg, Kans.; Frank E. Wellman, Kansas City; Arthur E. Wells, Salt Lake City, Utah; J. B. Wesley, Little Rock, Ark.; W. A. Whitaker, Lawrence, Kans.; H. E. Whiteley, Kansas City; Edward Wickers, Urbana, Ill.; F. V. Widger, Kansas City, Mo.; Jas. E. Wildish; E. A. Wildman, Indianapolis, Ind.; R. C. Wiley, Manhattan, Kans.; Lester T. Wilson, Chicago, Ill.; James R. Withrow, Columbus, Ohio; James A. Yates, Pittsburg, Kans.; Don O. Yeoman, Hutchinson, Kans.; C. C. Young, Lawrence, Kans.; Mr. Young, Kansas City, Mo.; A. Raymond Young, Lawrence, Kans.; Miss Zelma Zentmire, Ames, Iowa; Harper F. Zoller, Manhattan, Kans.

Co-operative Metallurgical Research.—The Massachusetts Institute of Technology has made an agreement with the United States Smelting, Refining & Mining Company, whereby the latter is to avail itself of the laboratory facilities offered by the institute instead of establishing a research laboratory of its own. The Institute of Technology has appointed Henry M. Schleicher, a graduate of 1910, to be research associate in charge of the work, the general direction resting on Prof. H. O. Hoffman, professor of metallurgy, in charge of the department of mining and metallurgy.

Benzene, Toluene and Xylene from Petroleum*

By Gustav Egloff

In this world struggle upon which our country has launched itself two substances stand out in bold relief as fundamental in the successful prosecution of this war. These two substances are benzene and toluene. Benzene forms picric acid; and toluene forms trinitrotoluene, two of our most powerful explosives.

Our need for these two fundamental substances will soon become acute in this struggle and it is quite certain that the present number of by-product recovery plants, carburetted water gas plants, Pintsch gas machines or plants for the thermal decomposition of coal for illuminating gas, which in the main give us our present supply of benzene, toluene and xylene, will be inadequate to supply the tremendously increased need of these substances. The carburetted water gas and Pintsch gas processes produce aromatic hydrocarbons as benzene, toluene and xylene by the thermal decomposition of petroleum distillates, but they are not operated as a rule for the light oil which contains the aromatic hydrocarbons, benzene, toluene and xylene, but for the gas which requires a certain illuminating value instead of a heat value, in all but about fourteen states.

It is hoped that a knowledge of aromatic hydrocarbon formation from petroleum will help in plant practice; so as to produce maximum yields of benzene, toluene and xylene which will be sorely needed in the coming struggle.

For ninety years men have researched fitfully upon aromatic hydrocarbon production from fish, vegetable and petroleum oils. In that epoch-making paper of 1825 Michael Faraday, when analyzing the cracked oil resulting from the thermal and pressure decomposition of a fish and vegetable oil for gas making, described the discovery of a new compound which he called bicarburet of hydrogen or what is known as benzene.

Up to 1870 very little work was done until Letny isolated from the cracking of Baku residue benzene, toluene, xylene, cumene and naphthalene. In 1886 Armstrong, bending his energies toward analysis of a Pintsch gas light oil, gave the following products: benzene, toluene, xylene, trimethyl benzene and naphthalene.

A tremendous impetus was given to the cracking of petroleum oils for aromatic production in Russia due to stern economic necessity. In Russia economic coal is scarce and oil abundant. To convert part of their oil into aromatics for dye production was the goal set by the Nobel Brothers. The Russian chemists, led by Nikiforoff, solved the problem and no doubt his process for the production of aromatics for explosives is in operation at the present time.

But the first systematic work upon aromatic compounds from petroleum in the modern era was carried out by Dr. W. F. Rittman. His paper may be found in the 1915 *Journal of Industrial and Engineering Chemistry.*

From the history of the production of aromatic hydrocarbons by cracking petroleum, the following conclusions may be drawn:

1. Low temperatures produce more toluene and xylene than benzene and no naphthalene.

2. Moderately high temperatures yield more benzene than toluene and xylene, with appreciable yields of naphthalene and anthracene.

3. High temperatures result in large percentages of

*Address made at the American Chemical Society Spring meeting at Kansas City, Mo., April 10, 1917, in the Symposium on Natural Gas and Petroleum (Public Session).

naphthalene and anthracene, and relatively smaller percentages of benzene, toluene and xylene.

In the past few years intensive work has been carried on to derive some knowledge as to the direction of aromatic hydrocarbon formation from that tremendous storehouse of hydrocarbons—*petroleum*.

In that period of time mixtures of ethane, propane and butane—natural gas condensate; pentanes and hexanes—petroleum ether; gasoline boiling to 150 deg. C.; kerosene boiling from 150 to 250 deg. C.; gas oil, boiling range, 200 to 350 deg. C.; paraffin wax with a melting point of 47 deg. C.; lubricating oils of various kinds; naphthene base oils and petroleum crudes, have all been subjected to temperature and pressure conditions of cracking. They all have formed aromatic hydrocarbons under right conditions. In short we can state with emphasis that all paraffin base oils or their distillates form aromatic hydrocarbons upon thermal treatment. Up to the present only one paraffin has resisted aromatic formation; this paraffin hydrocarbon being the first member of the series, methane. But there is no doubt that at a sufficiently high temperature methane will decompose to form benzene and toluene. Bone and Coward have formed acetylene upon thermal decomposition of methane and we know from the work of Berthelot, Fisher and others that acetylene polymerizes readily to benzene.

From the collective data of all the workers in the field of hydrocarbon chemistry it is quite within the facts to state that the course of aromatic hydrocarbon formation takes place somewhat as follows, from the thermal decomposition of paraffin base distillates.

High and low boiling point paraffin hydrocarbons

↓

Low boiling point paraffin and unsaturated hydrocarbons

↓

Naphthenes (alicyclic hydrocarbons)

↓

Aromatic hydrocarbons as

benzene ← toluene ⇆ xylene

↓ ↓ ↓

diphenyl benzene naphthalene

↓

diphenyl benzene

↓

triphenylene

↓

hydrogen and carbon

It must be recognized that the above distillates upon cracking, do not give the same percentage of aromatics on the basis of 100 gal. of oil used. It is true they all give benzene and toluene in maximum percentage for each group, but the variation may run as high as 500 per cent difference in yield. The percentage yields depend upon the constituents present in the oil. But, on the other hand regardless of the group of paraffin oils subjected to proper thermal conditions, the products formed are aromatic hydrocarbons.

It is well known that every chemical reaction is a function of the concentration of the starting material, temperature, pressure, time of reaction and catalysers.

The factors to be covered in this address will be temperature, pressure, the time factor and the starting oil or concentration.

The Effect of Temperature on Benzene, Toluene Xylene, Napthalene and Anthracene Formation

The starting material used was a gas oil with a boiling-point range of 92.3 per cent between 200 deg. and 350 deg. C. and the specific gravity of 0.817 at 15.5 deg. C.

The effect of temperature upon the percentage yield of benzene, toluene, xylene, naphthalene and anthracene at atmospheric pressure and in the gas phase is clearly brought out in Table 1, on basis of oil used:

TABLE 1

Temperature, Deg. C.	Per Cent Benzene	Per Cent Toluene	Per Cent Xylene	Per Cent Naphthalene	Per Cent Anthracene
450	0.0	0.0	0.0	0.0	0.0
500	0.0	0.2	0.2	0.0	0.0
550	0.0	0.6	0.3	0.0	0.0
600	0.5	1.4	0.6	0.0	0.0
650	2.5	3.1	1.4	0.0	0.0
700	3.3	2.2	1.9	0.0	0.0
750	4.7	2.0	1.6	1.3	0.0
800	4.4	1.5	1.2	2.0	0.3
875	1.1	0.1	0.06	1.5	0.2

It will be noted that the maximum yield of toluene was found at 650 deg. C. giving a percentage of 3.1 whereas the maximum of 4.4 for benzene took place at the higher temperature of 800 deg. C. The xylene formed in greatest percentage at 700 deg., giving a value of 1.9 on the basis of 100 gal. of oil used. No naphthalene formed until 750 deg. C. while a still higher temperature was required to form appreciable quantities of anthracene. All the aromatics show a maximum formation of percentage yield at a definite temperature. Of all the factors involved in the cracking of hydrocarbon oils, temperature is probably the most important. For relatively small changes in temperature, the percentage yields of benzene, toluene, xylene, naphthalene or anthracene, are greatly changed. Temperature control in cracking reactions is of primary importance.

The Effect of Pressure on the Formation of Benzene, Toluene and Xylene

Both the effect of pressure and temperature are clearly brought out in the data pertaining to a naphthene base oil. The naphthene base oil was subjected to temperatures from 550 deg. to 700 deg. C. at two pressures. The pressures used were one and eleven atmospheres. The oil used was practically a natural lubricating oil giving a boiling point range of 91.9 per cent between 150 deg. and 335 deg. C. and a specific gravity of 0.847 at 15.5 deg. C.

This naphthene base oil has given without doubt the highest percentage yield of benzene, toluene and xylene of any petroleum distillate studied up to the present time.

The data are given in Table 2.

TABLE 2

Temperature, Deg.C.	550		600		650		700	
Atmospheres	1	11	1	11	1	11	1	11
Per cent benzene....	0.9	0.4	0.9	2.0	2.6	7.2	4.2	6.5
Per cent toluene....	2.0	2.1	2.2	6.1	4.0	5.9	4.5	3.3
Per cent xylene.....	2.3	3.3	2.7	5.9	3.4	5.1	2.0	2.3

An increase of pressure upon the thermolized oil had a marked effect on the percentage yields of the individual hydrocarbons benzene, toluene and xylene. In a number of cases the yield of a specific aromatic was increased over 250 per cent, by increasing the pressure from one to eleven atmospheres. As will be noted, at 600 deg. C. the percentage of toluene at atmospheric pressure gave 2.2 whereas an increase to eleven atmospheres yielded 6.1 on basis of oil used; and under the same conditions the percentage of xylene increased from 2.7 to 5.9 per cent. At 650 deg. C. the benzene increased from 2.6 to 7.2 per cent with increase from one to eleven atmospheres. In general increase of pressure increases the percentage yield of aromatic hydrocarbons and decreases the unsaturated hydrocarbon formation simultaneously.

The Time Factor in the Formation of Benzene, Toluene and Xylene

The time factor or rate of oil flow into the heated area in gallons is of great importance in all hydrocarbon reactions. The length of time in which the gaseous hydrocarbons are in the heated area can be readily governed by the rate of oil flow and by keeping the heated area of the cracking zone constant.

A gas oil was used in the following experiments: The rates of oil flow were 6, 12, 16, 23, 30 and 36 gal. per hour. An 8-in. diameter lap-welded steel tube 11.6 ft. in length was kept at temperatures of 400, 450, 500, 550, 600, 650, 700 and 750 deg. C. and at a pressure of eleven atmospheres. One of the significant points of the data in Table 3 is the fact that the formation of benzene, toluene and xylene occurs at as low a temperature as 400 and 450 deg. C. Their formation cannot be ascribed to the phenyl radical being present in the oil. The starting oil was carefully tested for aromatics and the specific gravity 0.820 at 15.5 deg. C. of the oil being too low, and with nitration and sulphonation tests no nitro derivatives or sulphonic acids were found. If the phenyl radical was present it could be present only to a minimal extent and would not account for the percentage yields of benzene, toluene and xylene formed at these low temperatures.

Table 3

Percentage of Benzene, Toluene, Xylene on the Basis of Oil Used for Production

Rate, Gals. Per Hour	6	12	16	23	30	36
Temperature, Deg. C.						
			Per Cent Benzene by Volume			
400	0.0	..	..	..	..	..
450	1.4	0.0	0.3	0.0	..	..
500	..	1.0	..	0.2	0.0	0.0
550	..	3.6	1.6	0.3	0.6	0.0
600	..	4.2	4.1	0.9	0.8	1.2
650	..	4.6	6.6	3.7	1.2	..
700	..	..	..	6.2	5.4	3.2
750	..	..	..	..	5.7	5.8
			Per Cent Toluene by Volume			
400	1.5	..	..	..	..	..
450	3.1	1.4	2.9	0.5	..	..
500	..	2.4	..	1.6	1.8	0.9
550	..	3.9	3.7	1.5	2.5	1.4
600	..	2.7	4.4	2.3	2.0	3.0
650	..	2.2	4.1	4.1	2.4	..
700	..	..	..	3.2	3.1	3.5
750	..	..	..	..	4.4	4.5
			Per Cent Xylene by Volume			
400	1.6	..	..	..	..	..
450	3.2	1.3	2.3	0.8	..	..
500	..	2.0	..	1.6	1.0	1.4
550	..	2.6	2.6	1.4	2.2	1.1
600	..	1.1	3.4	1.3	1.8	2.4
650	..	0.6	1.8	2.4	1.7	..
700	..	..	..	1.5	2.3	3.0
750	..	..	..	..	2.5	2.4

From the data it can be readily noted, how important is the rate of oil flow into the heated area in forming aromatic compounds in appreciable yields. Within the gallonage per hour studied here, the percentage yield of benzene decreased as the rate increased in general. The formation of toluene and xylene increased to a maximum and then decreased with increase of the gallonage per hour. This indicates that to form benzene in higher percentage yields, the gaseous hydrocarbons of the starting oil must remain in the heated area a longer time or a low gallonage per hour must be used. In short there is an intimate relationship between the time factor and the temperature of the hydrocarbon reaction while keeping the other conditions constant. The time factor has been overlooked in many published researches, which makes it exceedingly difficult to compare the respective data and may account for some of the discordant results one finds in the literature of cracking reactions.

Recracking of a Cracked Oil

In the industrial operation of carburetted water gas, Pintsch gas and cracking processes in general which form aromatic hydrocarbons, when the aromatics after the first cracking are separated, there is left a residue oil, disposition of which at a profitable figure is sometimes difficult. There is a conflict of opinion as to how many times an oil can be cracked profitably for the formation of gasoline, benzene, toluene and xylene. To throw light upon this point a Pennsylvania crude gas oil was subjected to temperatures of 550, 600, 650 and 700 deg. C. and pressures of one and eleven atmospheres respectively. These same conditions of temperature and pressure were applied to the same oil which had been cracked but the light oil boiling to 200 deg. C. and the 20 per cent of pitch which it contained, first being removed. The experimental results are given in Table 4.

Table 4

A Comparison of the Effect of Temperature at One and Eleven Atmospheres Pressure on the Per Cent of Benzene, Toluene, Xylene, Naphthalene and Anthracene on the Basis of Petroleum and Cracked Oils Used for Production

Temperature, Deg. C.	550		600		650		700	
	Pet. Oil	Cracked Oil	Pet. Oil	Cracked Oil	Pet. Oil	Cracked Oil	Pet. Oil	Cracked Oil
	One Atmosphere Pressure							
Per cent benzene....	0.0	0.1	0.5	1.0	2.5	1.9	3.3	2.7
Per cent toluene....	0.6	1.3	1.4	2.1	3.1	2.2	2.2	2.1
Per cent xylene....	0.3	1.6	1.0	2.4	1.4	3.0	1.9	2.4
Per cent naphthalene	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.4
Per cent anthracene	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6
	Eleven Atmospheres Pressure							
Per cent benzene...	0.7	0.4	4.5	2.5	7.6	2.9	6.8	3.3
Per cent toluene...	2.7	1.4	4.6	3.4	3.2	2.8	2.2	1.3
Per cent xylene....	0.0	1.8	3.0	3.5	1.4	2.8	1.4	1.2
Per cent naphthalene	0.0	0.0	0.0	0.0	2.9	trace	2.2	4.2
Per cent anthracene	0.0	0.0	0.0	0.0	0.0	trace	0.2	0.8

There can be but one answer as to results of thermolizing a cracked oil. These can be deduced from the nature of the cracked oil itself and from data obtained in the cracking of different type oils. Depending upon the extent to which the decomposition produced by temperature and pressure has taken place, a recovered oil is obtained which contains aliphatic and aromatic hydrocarbons in proportions corresponding to these conditions. If the reaction is carried far enough, it is possible to obtain a cracked oil which is composed almost entirely of aromatic hydrocarbons. The cracked oil studied in this connection was made under conditions which gave a mixture of aliphatic and aromatic hydrocarbons. From the data of cracking dead and creosote oils resulting from the thermal decomposition of coal, it was learned that they do not decompose appreciably into low-boiling-point hydrocarbons. Hence the cracking of an oil which has already been thermolized should not give as good results for gasoline formation or for aromatics such as benzene.

Therefore one can argue that the low-boiling-point hydrocarbons resulting from the cracked oil used, came from the unchanged petroleum present in the cracked oil. Since the cracked oil only contained a percentage of unchanged petroleum the cracking will not produce as much gasoline or benzene, toluene and xylene as would the thermolization of the original petroleum oil. It would also be expected that more carbon would be formed from the cracked oil because any cracking of the aromatics present would go mainly to carbon and gas, and complex polycyclic aromatic hydrocarbons.

This brings us to the conclusion that all petroleum crudes will not crack into commercial percentages of gasoline, or aromatics due to some petroleum crudes already being thermolized partially or wholly in the earth. In other words, a cracked oil is not as favorable

an oil, for gasoline, benzene, toluene, xylene formation as an uncracked oil.

In an attempt to apply the data on the formation of aromatics gleaned from cracking in the gas phase in steel tubes, a number of tests were made upon a Lowe carburetted water gas set. The following results were obtained after a twenty-four hour run at four different temperatures at the base of the superheater. The gas oil used gave a specific gravity of 0.829/15.5 deg. C. and boiling point range of 93 per cent between 175 deg. C. and 345 deg. C.

TABLE 5
Per Cent of Benzene, Toluene, Xylene, Naphthalene and Anthracene on Basis of Oil Used for Production

Temperature, Deg. C.				
Base of superheater	600	675	750	800
Per cent benzene	1.0	1.2	1.8	2.8
Per cent toluene	2.1	2.6	2.7	2.7
Per cent xylene	2.1	3.4	3.0	2.1
Per cent naphthalene	0.0	0.0	1.9	2.0
Per cent anthracene	0.0	trace	0.1	0.9

Cracking in a standard Lowe 6-ft. set gave results somewhat lower than thermolizing in a steel tube, but this is readily explained in part on the ground of difference in the starting gas oil, and the differences in apparatus and rate of oil flow. In the four tests, maximum conditions were certainly not obtained, but the course of the reaction is exactly the same as when using a steel tube 8 in. diameter and 11.6 ft. in length.

Carrying the tests further, the gas from the 800 deg. C. run was scrubbed by passing through an absorbent oil. The amount of gas passed through the scrubber was 1000 cu. ft. The absorbing oil was then steam distilled and the light oil recovered, was analyzed for its benzene, toluene and xylene content.

In round numbers the gallonage of benzene, toluene and xylene per 1000 cu. ft. gave:

0.07 gal. benzene per 1000 cu. ft. gas scrubbed
0.06 gal. toluene per 1000 cu. ft. gas scrubbed
0.01 gal. xylene per 1000 cu. ft. gas scrubbed

Now, these figures do not appear at first glance to have much economic value, yet they are interesting when one considers that according to Lesher's report published in the Geological Survey there were made in the United States 124,129,569,000 cu. ft. of carburetted water gas in 1915.

Now, by making a national heat standard for gas, while a heat standard is used only in fourteen states or so at present, these fundamental substances could be recovered. At present with few exceptions the gas is burned with illuminating standards.

A few plants scrub the gas from carburetted water gas, but the bulk do not.

By putting in a simple scrubbing system and stills in carburetted water gas plants in this country the total gallonage of benzene, toluene and xylene which could be recovered per year on the basis of the 1915 report would be as follows:

Gallons benzene	8,689,000
Gallons toluene	7,448,000
Gallons xylene	1,241,300

in round numbers.

At present prices of benzene, toluene and xylene the economic value of the above gallonage would be:

Value of benzene based upon a present price of 0.55 per gallon, $4,779,000. Value of toluene price 1.75 per gallon, $13,034,000. Value of xylene at 0.60 per gallon, $744,600.

The present prices of aromatics were taken as the low quotation of the April 2, 1917, copy of the *Oil, Paint & Drug Reporter.*

In round numbers the saving in economic value at present prices of the three aromatic hydrocarbons from carburetted water gas scrubbed would be $19,000,000.

And we must recognize the fact that these figures are based upon the 1915 census. It is quite safe to say that this amount has increased about 20 per cent since that time, this being based upon an extrapolated value from previous years.

In this report only the benzene, toluene and xylene resulting from the thermal and pressure decomposition of petroleum oils has been given. This is a prolific and almost inexhaustible supply for the fundamental substances in explosives, and will fully yield all that this present war may demand. Coal, as all know, yields tremendous quantities, but there is a part of the light oil which is also a prolific source for the production of benzene, toluene and that is xylene. And it yields readily to benzene, and toluene formation by heat, and pressure treatment, as also with catalysers at low temperatures.

CONCLUSIONS

1. All groups of paraffin hydrocarbons have formed benzene and toluene upon thermal treatment with one exception, methane.

2. We can control the yields of aromatic hydrocarbons so as to form benzene, toluene, xylene, naphthalene or anthracene in maximum quantity.

3. The group of paraffin hydrocarbons present in the petroleum distillate is of great importance in forming aromatics in large yields.

4. All paraffin hydrocarbons form aromatics but with varying percentage yields, on basis of oil used.

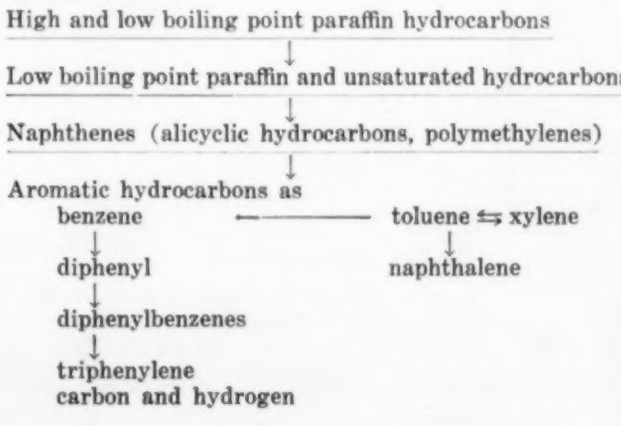
5. The temperature at which the petroleum oil is cracked is of primary importance in giving maximum yields of benzene, toluene, xylene, naphthalene and anthracene. The effect of pressure and the time factor is of lesser importance within limits than temperature. But, the three factors of temperature, pressure and time are intimately related and a nice balance must be held to yield maximum percentages of aromatic hydrocarbons.

6. A cracked oil is not so well adapted to aromatic or gasoline production as is a petroleum oil.

7. Whatever cracking takes place to lower boiling point hydrocarbons from a cracked oil may be attributed to a large extent to unchanged petroleum in the cracked oil and not to its aromatic constituents.

8. There is a limit to the number of times which an oil can be recracked, because of the tendency of the reaction to form aromatic compounds which decompose neither into gasoline nor members of the benzene series appreciably, but toward the ultimate products, hydrogen and carbon.

9. The course of aromatic hydrocarbon formation from paraffin base petroleum distillates in all likelihood is as follows:



The Embrittling Action of Sodium Hydroxide on Mild Steel and Its Possible Relation to Seam Failures of Boiler Plate

By Paul D. Merica

For some time past the Engineering Experiment Station of the University of Illinois has been making an investigation into the causes of the seam failures of boiler plates, which have been occurring there and elsewhere in that part of the country. The author was engaged during the early part of 1914 in this investigation, and studied at that time the possible deteriorating effect of alkali on the steel of the plates, following an idea advanced by Prof. S. W. Parr. It seemed advisable to delay the publication of the results of this investigation until further work at the station, described by a Bulletin of the Station just issued, should relate if possible more fully the action of the alkali on steel to the actual boiler failures.

The author wishes to express his appreciation of the very cordial co-operation and aid of Prof. S. W. Parr and of Prof H. F. Moore; Dr. T. E. Layng aided most efficiently in most of the testing work.

THE CHEMICAL ACTION OF SODIUM HYDROXIDE UPON IRON AND STEEL

It is well known[1] that at ordinary temperatures iron is passive or non-reactive to hydroxide solutions having OH ion concentrations in the range of approximately 10^{-1} to 2N sodium hydroxide. However, if the concentration of the hydroxide is increased the passivity vanishes and a reaction of the sort indicated below may take place. This is shown by the electrolytic potential of iron to solutions of sodium hydroxide or potassium hydroxide. A curve, Fig. 1, is reproduced from Heyn and Bauer's work,[2] showing the emf. at ordinary temperatures of iron to solutions of varying hydroxide concentration. It is seen that an anodic reaction of the type

$$Fe + xOH = FeO_x + xH$$

becomes possible at hydroxide concentrations of about 5-10 N. At higher temperatures the reaction between sodium hydroxide and iron is more rapid, and Krassa[3] has shown that hydrogen gas is generated by the action of N sodium hydroxide on steel at 150-200 deg. C. We may expect then at higher temperatures to obtain hydrogen by the action on steel of sodium hydroxide of at least higher concentrations.

[1]Heyn-Bauer, Mitt. a.d. Kgl. Materialprüfungsamt, 1908.
[2]Stahl und Eisen, 1908.
[3]Zeitschrift für Elektrochemie, 1909, p. 490.

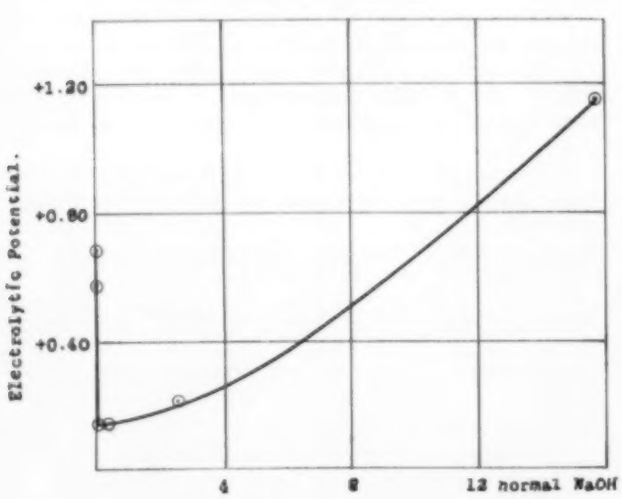


FIG. 1—THE ELECTROLYTIC POTENTIAL OF IRON TOWARD SODIUM HYDROXIDE SOLUTION (ACCORDING TO HEYN AND BAUER)

Abscissas—Concentration of NaOH in mols per liter
Ordinates—EMF of Fe/NaOH/normal calomel electrode

THE EFFECT OF NASCENT HYDROGEN UPON THE PHYSICAL PROPERTIES OF STEEL

The researches of Ledebur[4] on the so-called "pickling brittleness" have shown that very marked brittleness is produced in steel by treatment with dilute acid or by making it the cathode in an electrolytic cell. In both cases "nascent" hydrogen is generated on the surface of the steel, and reacts with it in some way not yet clear to produce a material which is much less tough than the original steel. The analogy of the two cases is now apparent, and it is not surprising to find that in fact the action of sodium hydroxide on steel at higher temperatures, at which this reaction first proceeds with appreciable velocity, produces a brittleness comparable with the "pickling brittleness" and which is due to the same cause.

In Ledebur's study of this type of brittleness he found that it was not possible by the static tensile or compression test to show the deterioration which took place upon generating nascent hydrogen on steel. The various quantities measured, including elongation and reduction of area remained practically unchanged. Some slight change was detected by a transverse static test, but when an alternating stress or an impact test was used the deterioration was at once very definitely indicated by reductions of 25-75 per cent of the toughness as so measured. It was for this reason that it was decided not to rely alone upon a tensile test in this investigation, but to include also some form of impact and alternating stress test.

There is reference in the literature to the effect that sodium hydroxide has a "destructive effect" on mild steel,[5] but the author has unfortunately been unable to obtain this article, in which description is given of the deterioration of steel exposed to hot alkaline solutions.

An article by Andrews recently appeared[6] in which the author showed by some simple bending tests the effect of treatment of small strips of iron with hot alkali. He states that a thin strip of mild steel became very brittle and "crystalline" after immersion for one week in sodium hydroxide solution at 100 deg. C., and advances a theory to account for it, to which reference will be made later.

DESCRIPTION OF TESTS, MATERIAL, ETC.

The physical tests were carried out with small test specimens. Whatever effect the alkali has upon the steel is likely to be localized at the surface; in order that the tests may be sensitive a large ratio of surface to volume or cross-section is desired.

The Tensile Tests were carried out on a 10,000-lb. Olsen machine, using the same speed for all tests; an automatic recording device was attached and the area under the stress-strain curve determined. The specimens possessed a diameter of 0.150 in. over a test length of 1.25 in.

The Impact Tests were carried out with an apparatus assembled at the station, of which a photograph is shown in Fig. 2. The weight of the pendulum hammer was 16.5 lb.; the height of fall of its center of inertia, 24.6 in.; the round specimens, 4.5 in. long, were notched always with a right-angle tool on the lathe, and were

[4]Stahl und Eisen, 1887, p. 681; 1889, p. 745.
[5]Stromeyer, Manchester Steam Users' Association, 1910.
[6]Andrews, Transactions of the Faraday Society, March, 1914.

FIG. 2—IMPACT TESTING MACHINE

broken transversely. The specimens were machined to a uniform diameter on either side of the notch for a distance of 0.5 in.

During the preliminary work some rather interesting results were obtained showing the dependence of the specific impact work of rupture on the diameter of the specimen at the bottom of the notch and on that immediately adjacent to it. These results are shown graphically in the Figs. 6 and 7 (*d* represents the former diameter, *D* the latter). Values of 0.140 in. for *d* and 0.235 in. for *D* were chosen for the ensuing tests. With this machine, and under the conditions realized in the tests, values of the specific impact work could be checked to within from 10 to 15 per cent on specimens notched at the same time and under the same conditions.

The Alternate Stress Tests were made on a small bench lathe, the arrangement of which is shown in Fig. 8. The specimen was supported in a draw-chuck at one end, the load being carried by a bushing and ball-race frame at the other. The load was applied by means of a spring balance through a universal joint to the ball-race frame. The specimen had the shape shown in Fig. 4, the notch being cut with a right angle tool. The load was applied in each case with the same lever arm, and the number of alternations to rupture measured with a rotation counter, using a constant speed of about 120 revolutions per minute. The value of the load was so chosen that about 300 revolutions sufficed to rupture the specimen. Such a repeated bending test with small number of revolutions to rupture has undoubtedly been successful in indicating brittleness in many cases, in which the tensile test has failed to show any abnormal condition, as for example in the case of high phosphorus brittleness,[7] of pickling brittleness,[8] and in the case of overheated steel.[9]

Fig. 9 shows some results indicating the effect of varying the diameter at the base of the notch, keeping the other conditions constant; it was decided to use 0.195 in. as a value for *d*. Under these conditions variations in results on the same material did not usually exceed from 5 to 10 per cent, although occasionally much greater ones of 50 and even 75 per cent were noted.

[7]Kommers, Proc. Int. Soc. Testing Materials, 1912.
[8]Ledebur, loc. cit.
[9]Heyn, Handbuch der Materialienkunde, 1912.

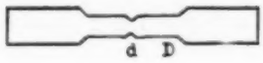


Fig. 3, Impact test specimen

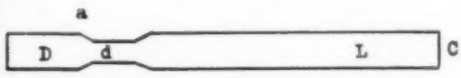


Fig. 4, Alternating stress test specimen

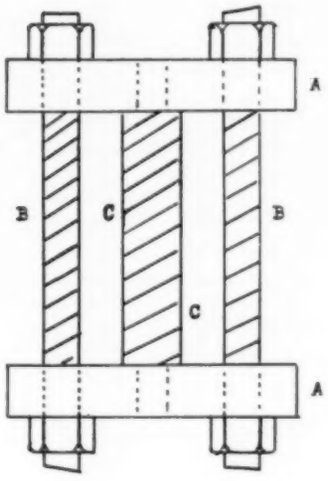


Fig. 5, Frame for subjecting specimens to action of alkali while under stress

CHEMICAL TREATMENT OF THE SPECIMENS

The action of the alkali, sodium hydroxide, was studied at three temperatures, 100 deg., 180 deg. and 280 deg. C., using in each case a constant concentration of 13.6 N alkali (except as noted in the tables). At the two higher temperatures the treatment of the

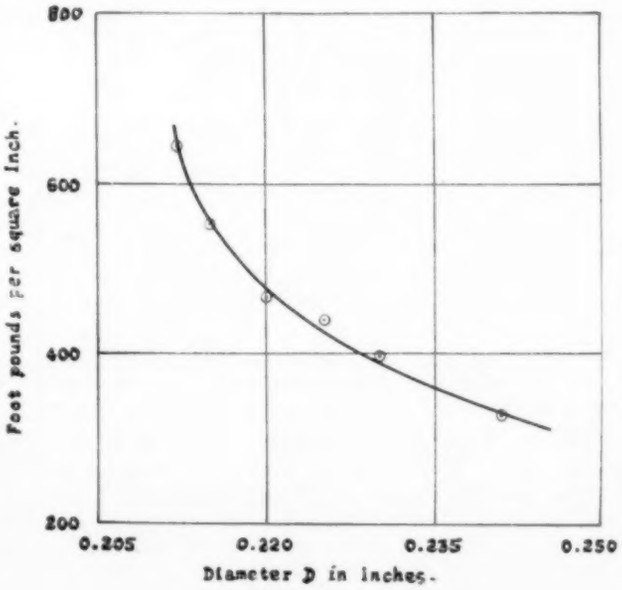


FIG. 6—THE IMPACT TEST

Effect of variations in the diameter D of the specimen (D constant) on the specific impact work.
Abscissas—D in inches
Ordinates—Specific impact work in foot pounds per square inch

specimens could not be accomplished in a glass tube for the reason that the latter would be quite readily attacked by the alkali. It was necessary to use iron pipe for this purpose, and it was discovered that at these high temperatures it was not possible to make a pressure-tight joint with an ordinary pipe cap; such a joint will hold steam pressure at those temperatures, but when the alkali solution was used it would rapidly evaporate. It was necessary to weld the top of the pipe with the oxy-acetylene torch after the solution of alkali and the specimens had been put in.

Only one material was used in these tests, a ¼-in. steel wire of the following composition:

C	0.18 per cent
P	0.024 per cent
S	0.045 per cent
Mn	0.42 per cent

Five hundred feet of this wire were annealed in a gas furnace for test.

THE RESULTS OF THE PHYSICAL TESTS

Table I gives the results of the first series of tests, in which all values are expressed for the sake of convenience in terms of percentages of the corresponding values for the untreated material. The results of the impact and of the repeated bending tests are the averages of five tests, those of the tensile tests of two tests.

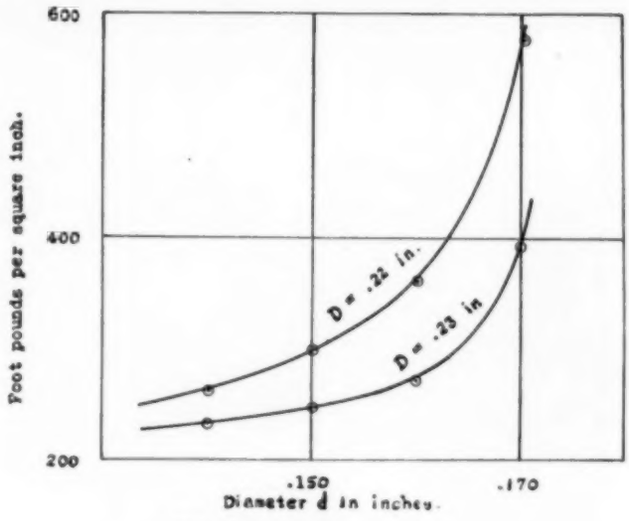


FIG. 7—THE IMPACT TEST

Effect of variations in the diameter d at bottom of notch (D constant) upon the specific impact work.
Abscissas—d in inches
Ordinates—Specific impact work in foot pounds per square inch

sodium hydroxide on the yield point or on the ultimate strength. The impression is gained from a study of the elongation that its value is lowered a few per cent

TABLE I—SERIES 1 OF TESTS SHOWING EFFECT OF ALKALI TREATMENT ON PHYSICAL PROPERTIES OF STEEL

Solution	Time of Treatment in Days	Temperature of Treatment, Deg. C.	Tensile Test: Yield Point, Lbs. per Sq. In.[1]	Tensile Test: Ultimate Tensile Strength Lbs. per Sq. In.[1]	Tensile Test: Elongation in 1¼ In., per Cent[1]	Area Under Stress-Strain Curve[1], per Cent	Alternate Bending Test, Number of Alternations to Rupture[1]	Impact Test, Specific Impact Work[1]	Hydrogen Evolution
13.6 N NaOH	17	100	116	102	100	112	85	92	.....
13.6 N NaOH	30	100	101	102	83	92	110	108	.....
13.6 N NaOH	10	180	110	100.5	98.0	110	64	....	Strong
13.6 N NaOH	15	180	100.8	102	97.4	107	69	....	Strong
13.6 N NaOH	15	180	103.0	98.5	82	88	82	....	Strong
13.6 N NaOH	19	180	80	97	88	92.5	82	100	Strong
13.6 N NaOH	23	180	....	....	....	....	88	100	Slight
13.6 N NaOH	24	180	....	....	....	....	90	88	Strong
13.6 N NaOH	12	180	....	....	....	....	....	....	Strong
13.6 N NaOH	5	280	100.6	98.6	104.0	113	79	....	.....
13.6 N NaOH	8	280	97.6	95.6	67.0	70	56	....	Strong
13.6 N NaOH	10	280	99.6	100.1	97.0	110	57	83	Strong
13.6 N NaOH	13	280	98.5	96.0	87.0	92.0	80	102	Strong
13.6 N NaOH	15	280	89.0	94.4	98.0	104	75	104	None
13.6 N NaOH	15	280	97.6	101.0	90.6	91	73	92	Slight
13.6 N NaOH	15	280	....	....	....	....	79	104	Strong
13.6 N NaOH	16	280	107	97	97	104	77	94	Strong
13.6 N NaOH	15	....	....	....	....	....	..	.. ..	Slight
13.6 N NaOH+$Na_2Cr_2O_7$	17	180	102	104	104	117	126	106	None
13.6 N NaOH+$Na_2Cr_2O_7$	19	180	116	105	101	116	105	102	None
13.6 N NaOH+$Na_2Cr_2O_7$	19	180	....	....	....	....	....	....	Yes
13.6 N NaOH+$Na_2Cr_2O_7$	17	280	96.5	101	87	94.5	119	86	None
13.6 N NaOH+$Na_2Cr_2O_7$	19	280	96.5	96	94	101	93	107	Slight
13.6 N NaOH+$Na_2Cr_2O_7$	20	280	....	....	....	....	..	..	None
Na_2CO_3	23	180	....	....	....	....	104	109	Some
Na_2CO_3	..	180	....	....	....	....	....	..	Some
Na_2CO_3	16	280	101	100	91	97	131	104	None
Na_2CO_3	24	280	....	....	....	....	..	....	None
Boiler scale	09	180	106	101	94	104	91	94	.....
Boiler scale	23	180	....	....	....	....	90	103	Strong
Boiler scale	19	280	....	....	....	....	..	....	Slight
Boiler scale	19	280	....	....	....	....	..	....	None

[1]The results are expressed in terms of percentages of the values on original untreated material.

Column 9 gives an indication of the amount of the evolution of H_2 during the action of solution, as evidenced by the amount of pressure developed. The material in the untreated state had a yield point at about 37,700 lb., an ultimate strength of 55,900 lb., and an elongation of 31 per cent on 1¼ in. The area under the stress-strain curve was 1190 ft.-lb. per cubic inch. The specific impact work in the bending test when a deep notch ($d = 0.150$ in.) was used was 248 ft.-lb. per square inch (5.36 mkg. per sq. cm.).

The results of the tensile test show no effect of the by treatment in sodium hydroxide, which can also be said, although to a less degree, of the area under the curve. At the same time the lowering is hardly very marked, many of the values being lowered only an amount easily within the experimental error.

When the results of the repeated bending test are considered, however, the effect of sodium hydroxide in embrittling is at once apparent, the number of alternations of stress withstood after treatment being on an average about 20 per cent lower than the values for the untreated material for the two higher temperatures.

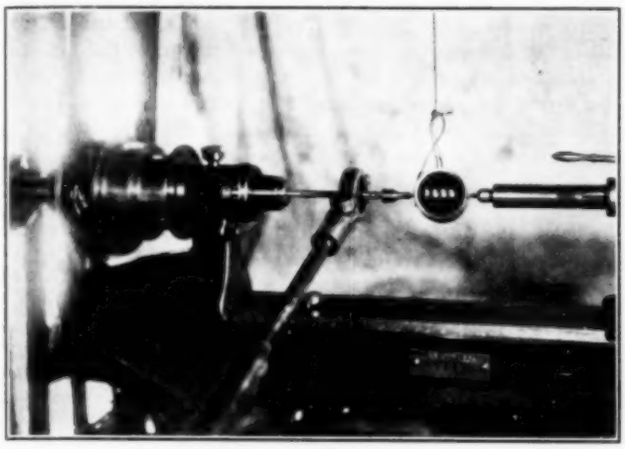


FIG. 8—ALTERNATE BENDING TESTING MACHINE

There are also only two cases in which there is no decrease.

In order to make these results more conclusive and at the same time to test the effect of time and temperature of treatment on the values obtained two more series of tests were run, the results being given in Tables II and III, and corroborating those of the first series.

The rather striking fact which is noticed in all the tests is that at both temperatures, 280 deg. C. and 180 deg. C., the brittleness increased up to about a week's time and then decreased, the material recovering either partially (first series) or even wholly (second series)

TABLE III—SERIES 3 OF TESTS SHOWING EFFECT OF ALKALI TREATMENT ON PHYSICAL PROPERTIES OF STEEL

Solution	Time of Treatment in Days	Temperature of Treatment, Deg. C.	Alternate Bending Test. Number of Alternations to Rupture[1]	Impact Test. Specific Impact Work[1]	Hydrogen Evolution
13.6 N NaOH	9	200	90	88	Strong
13.6 N NaOH	14	200	106	89	Strong
13.6 N NaOH	15	200	106	100	Strong
13.6 N NaOH	14	200	106	100	....
25N NaOH	15	200	82	86	Strong
N/10 NaOH	15	200	108	100	None
13.6N NaOH	9	200	106	104	None
13N $Na_2Cr_2O_7$	14	200	100	89	None
13N $Na_2Cr_2O_7$	15	200	....	108	None
25N NaOH	15	200	....	93	None
25N $Na_2Cr_2O_7$	....	....	....	....	....

[1]The results are expressed in terms of percentages of the values on original untreated material.

TABLE II—SERIES 2 OF TESTS SHOWING THE EFFECT OF ALKALI TREATMENT IN STEEL

Solution	Time of Treatment in Days	Temperature of Treatment, Deg. C.	Tensile Test			Area Under Stress-Strain Curve[1], Per Cent	Alternate Bending Test. Number of Alternations to Rupture[1]	Impact Test. Specific Impact Work[1]	Hydrogen Evolution
			Yield Point, Lbs. per Sq. In.[1]	Ultimate Tensile Strength Lbs. per Sq. In.[1]	Elongation in 1¼ In., Per Cent[1]				
13.6N NaOH	8	100	96	101	96	104	95	113	.....
13.6N NaOH	30	100	.....	.....	.....	.....	90	87	.....
13.6N NaOH	8	180	115	100	102	110	93	76	Strong
13.6N NaOH	3	280	.....	.....	.....	.....	83	97	Strong
13.6N NaOH	8	280	98	97	104	109	88	97	Strong
13.6N NaOH	8	180	100	102	90	97	103	100	None
13N $Na_2Cr_2O_7$	8	280	94	102	88	96	96	122	Slight

[1]The results are expressed in terms of percentages of the values on original untreated material.

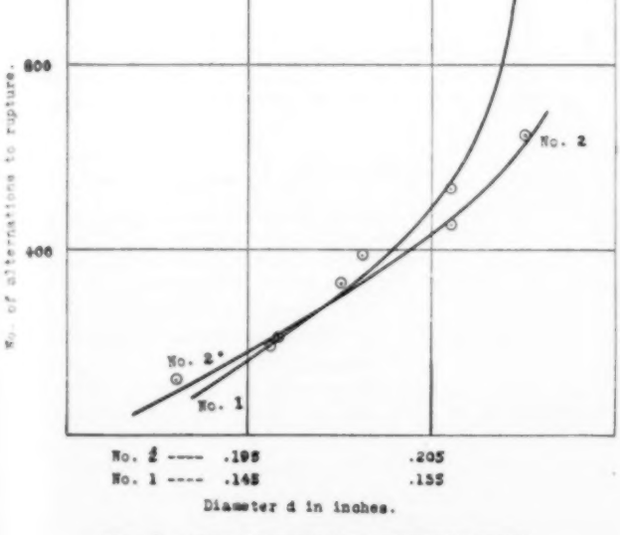


FIG. 9—THE ALTERNATE BENDING TEST

Effect of variations of d (D and M, the bending moment constant) on the number of alternations to rupture.
Abscissas—d in inches
Ordinates—No. of alternations to rupture

its original mechanical properties. This is indicated in the curves showing the results of the first series of repeated bending tests given in Fig. 10.

Even more striking is the complete recovery noted in the third series. This was also noticed by Andrews in his work, and there is advanced here a tentative explanation of this rather curious phenomenon. During the first period of the action of the alkali, before the oxide product of the corrosion has been formed, the hydrogen liberated by this action is actually given up in the nascent state *on the iron*, and absorbed by it. Later the H_2 formed by the anode solution of the iron is given up at the cathode, which is now the very electronegative oxide, and can come in contact with the iron itself only by secondary diffusion or after it has formed in the molecular state. Such hydrogen has been shown to have little or no effect on the mechanical properties of steel. Therefore, as soon as the oxide has formed in a thick and dense layer over and near the iron, the embrittling action of the chemical agent ceases. It has also been shown by Heyn (loc. cit.) and others that chemical (pickling) brittleness is relieved by heating for a short time at even such temperatures as 100 deg. C., the hydrogen evidently diffusing out of the material, leaving it as it was originally. Therefore, after the embrittling action of the alkali has ceased, that brittleness which has already been induced is removed by the heating to which the material is further subjected.

The effect of the temperature of treatment on the

results can be best seen from the Table II, from which it is evident that at the higher temperature the brittleness is developed in a shorter time than at the lower, and the effect produced by the alkali at this higher temperature seems to be greater also.

A survey of the results from the three tables shows, as would be expected, that the action of the alkali is more marked at the higher concentration of 25 N than at 13 N, and no effect at all is produced by the N/10 alkali at 200 deg. in two weeks, although there was quite noticeable corrosion.

As it has been suggested by Stromeyer in his article that steel in tension was more affected by treatment with sodium hydroxide than when without stress, and as such a fact would, under the circumstances, be of great significance, some tests were carried out to see whether such an acceleration of the embrittling action could be noticed. Two specimens were put in a frame, a sketch of which is given in Fig. 5. The specimens BB were then put in tension by screwing up the bolts, the amount of stress being approximately measured with a strain gage. Since the specimens were notched it was impossible to calculate the fiber stresses at the notch; the average stress applied to the bottom of the notch was about 15,000 lb. Three of these frames were then welded up with the solution in a 14-in. length of 4-in. pipe and heated the desired length of time. It was found very difficult to make this larger weld absolutely tight and free from pinhole leaks.

Table IV—Effect of Sodium Hydroxide Treatment on Soft Steel Under Stress

Solution	Time of Treatment in Days	Temperature of Treatment, Deg. C	Alternate Bending Test. Number of Alternations to Rupture[1]	Impact Test. Specific Impact Work[1]	Hydrogen Evolution
25N NaOH	8	183	76	86	
25N NaOH	8 (t)	180	95	65	
13N NaOH	14	190	97		Slight
13N NaOH	14 (t)	190	110		

[1]The results are expressed in terms of percentages of the values on original untreated material.

The results of these tests are given in Table IV in which the letter *t* signifies that those specimens were in tension during the treatment.

As far as can be seen from the results of the two runs made, the material in tension shows if anything less tendency to undergo the embrittling attack of the alkali than that which is not. In view of the conflicting testimony on this point (Stromeyer) it should be more thoroughly investigated.

Owing to the fact that the concentration of hydrogen is greatest at the surface and becomes less toward the center, the results of these tests probably do not give the proper evaluation of the amount of brittleness caused *at the surface*. Further, in turning down the specimen after the treatment about 15 per cent to 20 per cent of that material is removed which is most affected by the treatment.

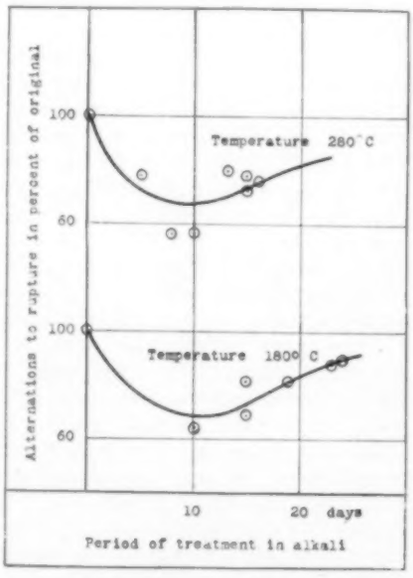


FIG. 10—EFFECT OF ALKALI TREATMENT AT HIGHER TEMPERATURES ON THE TOUGHNESS OF STEEL AS INDICATED BY THE ALTERNATING STRESS TEST

CAUSE OF THE EMBRITTLING EFFECT

There seems to be little doubt but that the embrittling effect of sodium hydroxide on steel above established is due, as suggested, to the absorption by the steel of nascent hydrogen. However, there are two other possibilities which may be considered here.

First, there is the possibility that the alkali actually works into the metal, eating out the "amorphous intercrystalline cement" which, being thermodynamically less stable than the crystals would be first attacked. This would cause a brittleness akin to that caused by burning or overheating, and fracture would be intercrystalline. Second, Andrews claims that sodium hydroxide causes a "crystallization," by which he means a coalescence of the smaller crystals into larger ones. This effect would then also be the same as that caused by overheating.

It is not believed by the author that sodium acts in this latter way, or at least that the embrittling effect is due to any such action. It is in the first place diffi-

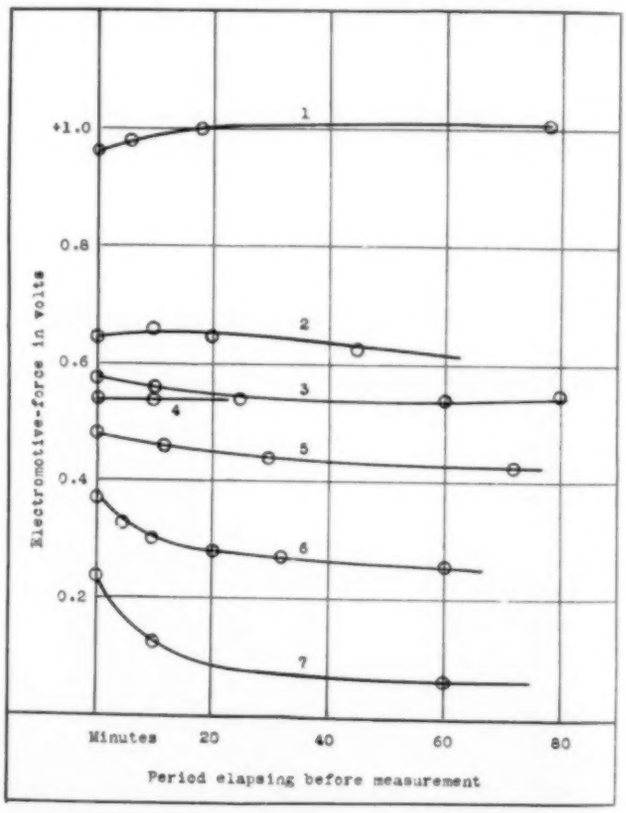


FIG. 11—ELECTROMOTIVE-FORCE OF STEEL UNDER VARIOUS CONDITIONS

Curve 1—EMF of steel to 13.6 N NaOH solution
Curve 2—EMF of steel to 0.1 N NaOH after treatment for 10 days in 13.6 N NaOH at 180 deg. C.
Curve 3—EMF of iron to 0.1 N NaOH after 10 minutes' immersion in dilute H_2SO_4
Curve 4—EMF of iron to 0.1 N NaOH after one week treatment with 50 per cent NaOH at 110 deg. C.
Curve 5—EMF of steel to solution which is 13.6 N both to NaOH and to $Na_2Cr_2O_7$
Curve 6—EMF of iron to 0.1 N NaOH in untreated state
Curve 7—EMF of steel to 0.1 N NaOH in untreated state
EMF's of curves 1, 2 5 and 7 were measured with the Hg/HgO, N/10 NaOH electrode, the others with the Hg/HgCl, N/10 KCl electrode
Curves 3, 4 and 6 are from data by Dr. Hirschkind

cult to see in just what manner the presence of sodium hydroxide could cause a coalescence to take place in the week's time which it takes to develop this brittleness at the comparatively low temperature of 100 deg. to 200 deg., in material in which the coalescence is known to proceed at an almost infinitesimally slow rate at these temperatures.

It has been further shown that the material in contact with sodium hydroxide at higher temperatures undergoes a gradual recovery of the original mechanical properties, a phenomenon which has already been given an explanation and which cannot possibly be reconciled with any theory making "recrystallization" responsible for this effect.

This explanation was, however, given some direct attention in the following manner. Pieces of the material used in the tests and also of electrolytic iron, about 1 in. long, were turned down to a uniform diameter and cut in two. One-half of the original specimen was then treated with the alkali, and the structures of the two compared, particularly at the edge exposed to the action of the alkali. No increase in grain size was noticed as a result of the treatment, even at the extreme edge of the specimen.

Attention has been called to the fact that hydrogen was evolved during the action of the alkali on the steel at all temperatures above 100 deg.; pressure was developed within the steel containing "bomb," the gas analyzing about 94 per cent hydrogen.

A rather striking proof of the fact that some molecular change takes place in iron during the action of alkali is found in a study of its emf. toward any strength of solution, more conveniently N/10 sodium hydroxide, before and after treatment in concentrated alkali at temperatures of 100 deg. and more. This matter was studied first by Dr. Hirschkind and later by the author, and it was found by both of us that this potential after treatment is considerably higher than that of the original material, and that it extends into the specimen from the surface for a considerable distance, which was proved by turning off from 0.015 to 0.030 in. before measuring. This increase in potential is also caused by immersion for a few minutes in dilute acids or by cathodic polarization.

The measurements, the results of which are shown in the curves in Fig. 11, were made by the ordinary compensation method. The specimens were in all cases sandpapered or turned down after alkali treatment, and paraffined for about 1 in. below and above the surface of the solution with which their potential was being measured. Curves 3, 4 and 6 are taken from Dr. Hirschkind's data; they show the potential in N/10 sodium hydroxide of steel against Hg/HgCl · N/10KCl as a function of the time. Curve No. 6 gives the potential for the untreated steel, No. 4 for the same after a treatment of one week in 50 per cent sodium hydroxide at 100 deg. C., and No. 3 the potential after about ten minutes immersion in diluted sulphuric acid. It is to be noted that cathodic polarization gives also the same effect as the latter. Curves 2 and 7 also show this effect, the measurements being in N/10 sodium hydroxide against Hg/HgO · N/10 sodium hydroxide, No. 7 shows the potential of untreated material, and No. 2 that after treatment for ten days in 13.6 N sodium hydroxide at 180 deg. The potential is seen to be in all cases higher after treatment of any sort that evolves nascent hydrogen on the steel than for the original material. This fact would seem to point unmistakably to a molecular change in the iron.

This high potential seems to disappear in many cases after some time and after heating to 100 deg.-200 deg. in air, but no relation was established between the presence of this potential and the existence of brittleness, as the potential seemed to be increased during the treatment long before the brittleness manifested itself.

PREVENTION OF THE EMBRITTLING EFFECT

Another demonstration of the truth of the hydrogen theory was found in studying means to prevent the deteriorative effect of sodium hydroxide. Of such means the first and most natural which suggests itself is the removal of the active agent, to a discussion of which reference will be made later.

If hydrogen is the cause of this brittleness, it should be possible to remove it by adding an oxidizing agent, as, for example, sodium dichromate, to the solution, which would depolarize the iron electrode. Preliminary measurements of the potential of iron to concentrated solutions of sodium hydroxide showed that at all temperatures readily accessible to such measurements (20 deg.-110 deg.) this potential was very considerably lowered by addition of the dichromate in equivalent proportions; that is, for 1 mol of sodium hydroxide there was used 1/6 mol of the dichromate. Curves showing this are given in Fig. 11, the measurements having been made at 80 deg. C. Not only is curve No. 1, which gives the potential of iron in 13.6 N sodium hydroxide, higher (more electropositive) than No. 5, which gives the same in a solution which is about 13 N to both the alkali and the dichromate, but it also slopes upward, while No. 5 slopes the other way. Since the hydrogen potential in an alkaline solution of this concentration is calculated to be about +0.930, it should be impossible for hydrogen to be generated in the solution in which the $Na_2Cr_2O_7$ is present. Similarly, judging from these data the corrosion in the dichromate solutions should be at least less well marked than the sodium hydroxide solutions alone. In order to settle these points parallel physical tests were run using the solution with equivalent amounts (13 N) of both the alkali and the dichromate. The results of these tests are given also in the Tables I, II and III.

It was first of all noticed in opening the pipes after the treatment that whereas, as has already been mentioned, H_2 was present in those which contained sodium hydroxide alone, only a few of the pipes containing the dichromate had generated hydrogen during the treatment. This is shown in the table. The corrosion in all cases was much less, being almost negligible in the case of less than a week's treatment at 180 deg., and was moreover of an entirely different character. This is shown in the photograph, Fig. 12. Whereas with pure sodium hydroxide the surface was rough and covered with a porous, loose deposit of black Fe_3O_4, or a hydrated form of it, which was at the higher temperatures 180 deg.-280 deg. in the form of a beautiful black crystalline sheen, with addition of $Na_2Cr_2O_7$ the surface was smooth and covered with a thin, dense, tightly adherent coating of brown Fe_2O_3. In the latter case the marks of the lathe tool were generally still visible, as can be seen in the photograph.

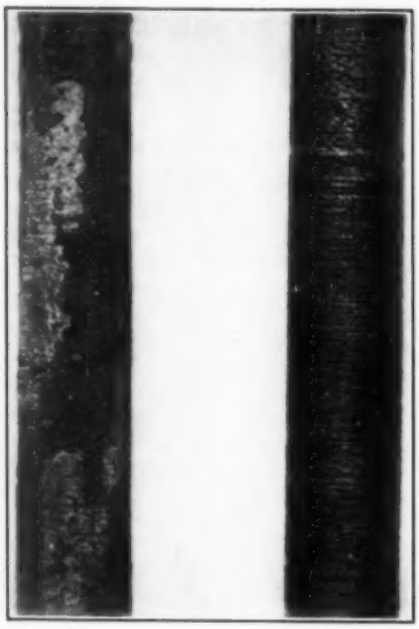
The toughness as indicated by the repeated bending test apparently suffers no deterioration under the action of sodium hydroxide and sodium dichromate in the periods of treatment used.

SEAM FAILURES OF BOILER PLATE

A type of failure which is related to the question discussed above is the failure of boilers at the seams and tube caps.[19] Fissures are found in such boilers, of the water tube type, at the seams of the steam drum

[19]These failures occurred in the university boilers and were noticed first in the summer of 1912.

and cross box, such cracks being on the inside of the seam, hence not easily visible and the more dangerous. An accompanying feature was the persistent leakage at these seams with formation of an alkaline incrustation. This phenomenon is as would be expected more marked at the front part of the drum and the cross box, where the temperature and stress changes are the greatest, and is to be found practically only below the water line.



A B

FIG. 12—THE CORROSION OF ¼-IN. STEEL WIRE

A—After one week in 13.6 N NaOH at 280° C.

B—After one week in { 13.6 N NaOH } { 13.6 N $Na_2Cr_2O_7$ }

Consultation with the builders of the boilers brought out the fact that there were to be found power plants in certain localities which were experiencing practically the same difficulty. The fact was also brought out by them that faulty material as a cause for these failures was scarcely to be considered, since not only different heats of material were to be found in the university boilers, but the parts were even assembled from different mills and steam manufacturers. Tests both physical and metallographic also showed that the material satisfied the specifications. For the same reason, namely, that this same type of cracking was noticed in so many different plants and under so many different conditions of installation and operation, the conclusion could be reached that there was some factor other than those mentioned which was responsible.

FIBER STRESSES AT SEAMS

As such a factor the question occurs at once as to the possibility of fault in construction. Of what magnitude are the stresses, both average and fiber, at the seams of a boiler, and in what measure is the material fitted to resist them? The material specified for boiler plate must have a tensile strength of from 55,000 to 65,000 lb. per square inch, and in modern boilers the construction is such that the average stress over the weakest section is about one-fifth of the ultimate strength, or, in other words, there is calculated to be a factor of safety of about five.

However, this factor of safety is probably fictitious only as several features in boiler operation and construction combine to lower it.

1. It has been shown by Rudeloff,[11] Martens[12] and others that although the ultimate strength of mild steel of the kind used in boiler plate is from 25 per cent to 35 per cent greater at the boiler operating temperature of 200 deg. C. than at ordinary temperatures, the yield point is about 15 per cent, the true limit of elasticity 25 per cent, and the elongation as much as 50 per cent lower than at ordinary temperatures; there is, in other words, a marked decrease in toughness at this temperature.

2. The fiber stresses at the seams of boiler plates have been shown [13, 14] to be from two to four times the average stresses, a fact which is more significant when these stresses are not purely static ones.

3. Heyn has made calculations of the stresses in boiler plate due to the variation in temperature across the plate section and finds that fiber stresses of from 10,000-30,000 lb. per square inch are possible.

Considering then the whole situation it is not improbable that the actual factor of safety at the seams in boiler plate design is not much above two.

FORMATION AND EFFECT OF SODIUM HYDROXIDE AT SEAM

The above considerations have been developed not as a possible cause and explanation for the trouble described, but merely to show that it might be quite possible that some slight flaw or some slight deterioration in the material could be the "straw that broke the camel's back," and that it is by no means necessary to seek to find some very marked or acute destructive factor in order to have a complete explanation for the phenomenon in question. That there was, however, an added factor in the situation is scarcely to be doubted, and that this factor is the embrittling action of aqueous sodium hydroxide is believed to have the weight of evidence.

Of interest is a consideration of the exact manner in which the material at the seams of boilers becomes actually subjected to the action of alkali. The reasoning leading up to the study of the action of alkali on steel is due, as mentioned above, to Prof. S. W. Parr.

One of the most prominent cases in which cracking of the plate of the sort above described had been noticed was in the power plant of the Solvay Process Company at Syracuse, and particularly in the caustic soda department. It was also discovered that in that locality around and near Champaign, where this difficulty had always been noticed, the fed water, which was fed untreated, contained sodium carbonate in very marked proportions, the feed water at the university, for instance, containing about 70 parts in a million. Now sodium carbonate has a very appreciable dissociation pressure of carbon dioxide at boiling temperature, and loses, according to Kuestner and Grueters,[15] 10 per cent of CO_2 in eleven hours if hydrogen is passed through the boiling solution. Sodium hydroxide will, therefore, under boiler conditions, be very rapidly formed from the carbonate, since the CO_2 can there very rapidly escape and equilibrium can never be reached. This conclusion was tested very simply by analyzing the water in several of the boilers, the results showing that from 50 per cent to 65 per cent of the sodium was present as the hydroxide, the amount of sodium hydroxide reaching as much as 400 parts per million—i.e., 1/100 N.

Sodium hydroxide of these low concentrations can have as above mentioned no appreciable effect on the mechanical properties of steel, but if this solution gets into the seams of the boiler and concentrates by leakage outward, solutions of caustic alkali of 50 per cent and more could easily be formed, and it is the action of such solutions which has been mainly investigated in this work.

There are certain questions which arise at this point.

First—How does the alkali get into the seams in the

[11] Stahl und Eisen, 1895.
[12] Stahl und Eisen, 1890.
[13] Leon, Osterreichische Wochenschrift für den öffentlichen Baudienst, 1909.
[14] Barraclough, Engineering News, Vol. 69.
[15] Ber. 1909, 748.

first place, since the initial concentration is so small—N/100—that no corrosion takes place at ordinary temperatures. It has been, however, shown that N/10 sodium hydroxide corrodes steel at 200 deg. in two weeks very noticeably, so it may not be expected that solutions which inhibit corrosion at ordinary temperatures also do so at the higher ones. Further the passivity of iron in alkali of these low concentrations is diminished by the presence of chloride, etc., to be found in ordinary boiler waters, such that corrosion may very possibly go on even at these low OH concentrations.

Second—Generally throughout the country boiler compounds, many of which have as a primary constituent Na_2CO_3 are being constantly used, without the impression having been gained that such compounds are in the least dangerous, whereas it would seem from the above that water treated in that way would have the same effect on boilers as the water with natural Na_2CO_3 present. It can only be pointed out in reply that persistent over-treatment would be necessary, since an excess of Na_2CO_3 over that amount required to precipitate the alkaline earth and heavy metals, calcium, magnesium and iron is required for the formation of sodium hydroxide. Further there is the not too remote possibility that the action of alkali is inhibited by other chemicals, which may be present in such waters, in the same way that sodium dichromate does. Some attention must in this connection be paid to the complication of the curious "recovery" of material after a certain time in contact with hydroxide. Finally it must be borne in mind, in considering why all boiler compounds containing alkali carbonates are not productive of failures, that the deterioration produced by alkalis is only one factor in a very complex situation, and that in order that failure may result these factors must combine toward this end.

EFFECT OF TREATMENT OF STEEL WITH SODIUM CARBONATE AND BOILER INCRUSTATION FROM FAILED BOILERS

It is interesting in this connection to consider the results of the treatment at high temperatures of steel with sodium carbonate solution, and with a solution made up with the boiler scale or incrustation which oozes through at the seams, responsible for the effect. Specimens were sealed up in the same way as with the alkali with concentrated solutions of Na_2CO_3, and with concentrated solutions of the scale formed and put in the furnace together with the others. It was not expected that either of them would even corrode the steel since measurements of the emf. of the steel at 100 deg. C. to these solutions had give values to $Hg/HgO \cdot N/10$ sodium hydroxide of about 0.135 for Na_2CO_3, and +0.125 for the scale, which are only slightly above the critical values (+0.100) established by Heyn[18] as the limiting ones below which no corrosion of steel takes place at ordinary temperatures. This was only partially borne out by experiment, as the specimens were corroded after over a week's treatment in these solutions at the two higher temperatures, this corrosion being slight in the case of the carbonate, and fairly well marked in the case of the boiler scale. Hydrogen was found present upon opening the Na_2CO_3 pipes from the 180-deg. treatment only, but the action of the solution of the scale was accompanied by evolution of this gas. The results of the physical tests on the specimens treated with these substances (see Table I) show that the former has no effect, while the latter causes a very definite deterioration in the mechanical properties of steel. This was not understood until an analysis of this scale showed the presence of from 1 to 5 per cent of sodium hydroxide, which had been prevented from changing to the carbonate in the air by inclosure in oil, which was also present. As this scale used had actually been taken from the caps and seams, and was found to produce a deterioration in the steel samples analogous to that produced by sodium hydroxide it is considered that these results go far toward linking up the practical boiler failure situation with the experiments which have been made on steel of boiler plate composition.

[18] Mitt. Kgl. Materialprüfungsamt, 1908.

CONCLUSION

It has been shown that alkaline solutions, such as those of NaOH act upon steel of low carbon content at higher temperatures in such a way as to produce brittleness of the steel as indicated by the alternating stress and the impact test, not noticeable in the tensile test however. This brittleness is probably due to the absorption of "nascent" hydrogen by the steel forming a less ductile or tough "alloy" with the hydrogen; it is relieved by annealing even at low temperatures. The effect of alkalis on steel is discussed in relation to the failures of boiler plates at the seams, occurring in localities where the water contains sodium carbonate; it is believed that these failures are due, at least in part, to this effect.

If such be the case, the elimination of such failures resolves itself into the question of the elimination of the alkali from the boiler water, or at least from the seams of the boiler. This could be done by the addition of ferrous or magnesium sulphates which would precipitate the carbonate or hydroxide in the water. It is also shown that the action of the alkali is to a large extent inhibited by the presence of sodium chromate, such that this substance could be advantageously used as an addition to alkaline boiler waters exercising this effect on the seams of the boiler plate.

Grain Size Determination and Standardization

By Zay Jeffries

In the April 1, 1917, issue of "Metallurgical and Chemical Engineering," page 378, Mr. George A. Miller, Jr., outlines a new adaptation of the comparison method for estimating grain size in methals. His ideas should be very welcome to metallographists.

In a paper before the Faraday Society, presented May 9, 1916, entitled "Grain Sized Measurements in Metals and Importance of Such Information," I have written as follows regarding the general method which Mr. Miller recommends:

"ESTIMATION OF GRAIN SIZE OF UNKNOWN BY COMPARISON WITH KNOWN SAMPLES.—This method is used by C. Grard[1] for controlling the work and annealing of copper and brasses. He first prepared a set of samples, treated mechanically and thermally under known conditions, and takes micrographs at certain suitable magnifications. The initial set of known samples should include all of the ranges of mechanical working and heat-treatment which will be encountered in practice. By taking an unknown sample and comparing its structure with that of the set of knowns, it is classified according to the size and the shape of the grains. In this way there need be no attempt to determine the number of grains per unit of area, as the relative number of grains may be all the information desired.

The control of carbon and phosphorus in certain iron and steel products will be recognized as a comparative method of grain-size determination. These determinations are made macroscopically on the fractures of the samples, and it is surprising how closely the carbon or phosphorus content can be estimated in this manner. The comparison method is the most flexible of all the methods, since it can be used to compare structures of all kinds."

[1] "Industrial Application of Microscopic Metallography for Controlling the Work Put on Copper and Brasses," International Association for Testing Materials, Sixth Congress, New York, 1912.

The ingenious manner in which Mr. Miller applies this method should not only make the comparisons more rapid, but should eliminate to a large degree the fatigue of the operator, which is one of the greatest drawbacks to any counting method. I think the comparison method as applied by Mr. Miller can be used for grain size estimations in metals and alloys other than brass. This method can be used in practically any field where grain size determinations in large numbers have been adopted as a matter of routine. It can also be used as a method of estimating the quantity of any given metallographic constituent, after the standards have been properly prepared.

The limitations of the comparison method should be indicated. A great amount of work is necessary for the proper preparation of the known samples. If only a few grain size determinations are desired it is doubtful whether the preparation of a set of standards is justifiable. Also samples will occasionally be encountered which have grain sizes outside the limits of the standards.

Where the number of grain size determinations is few or even for determining the grain size in the standard samples the following method[1] will be found both rapid and accurate.

This determination is made by projecting the image of the sample on to a screen or a ground glass and *counting the grains intersected by the circumference of a circle of standard diameter*, which is drawn on the screen or the ground glass and then *counting the grains which are completely included within the circle*. Referring to the boundary grains as w and the grains which are completely enclosed within the circle as z, the equivalent number of grains within the circle is

$$z + yw$$

where y is a factor which has been determined empirically on a large number of samples. This factor is 0.6. The size of the circle is so related to the magnification that the equivalent number of whole grains within the circle when multiplied by a whole number such as 100, 50 or 10 will give the number of grains per square millimeter on the samples.

It should be kept in mind that one of the chief advantages of the microscope lies in the fact that quick tests for uniformity either in grain size or composition can be made by its use. In order to test for uniformity of structure I usually make determinations at 5 points across a diameter of the sample. The results of each grain size determination are not known until after the determination is completed, that is, after the counts are made. In this manner a fair sample of the surface of the polished section of metal is obtained. When estimating grain size by the comparison method would not the operator unconsciously move the specimen slightly, for the last four determinations, so as to make the grain size compare as nearly as possible with the first determination? If this point is a factor, it is only of importance in samples which have appreciable grain size variations locally.

Regarding the numerical figures used to indicate the grain size there are two general systems.

1. Referring to grain size in terms of the *number of grains per unit area*, and

2. Referring to grain size in terms of the *diameter of the average sized grain.*

I have used the word "diameter" for want of a better word. In this place, it means the length of a side of a square having the same area as the average grain; it is the reciprocal of the square root of the number of grains per unit area.

[1] Trans. Am. Inst. Min. Eng., Vol. LIV, p. 594.

It would be advisable to standardize the unit of reference. Below are outlined the chief arguments for and against *area* as the unit of reference.

Arguments in favor of area as the unit for grain size reference:

1. The section which is being examined for grain size is an area, not a line.

2. All accurate direct grain size measurements are based on the determination of the number of grains exposed on a certain area.[2] The arithmetical operation of finding the reciprocal of the square root of the number of grains per unit area is a necessary step to obtain the diameter of the average grain.

3. The number of grains in a certain area is the actual thing determined, while the mean grain diameter has no real physical existence.

4. Grain size is more often referred to in terms of area than in terms of "diameter."

5. It is always desirable to use whole numbers in place of decimals or fractions. For example, to avoid the general use of decimals and fractions new units have been coined, such as mil, micron, millimicron, millivolt, etc.

The list of grain sizes given by Mr. Miller as his standards would be changed as in Table I.

TABLE I.

Diameter of Average Grain in mm.	Grains per Sq. mm.
0.025	1600
0.030	1100
0.040	625
0.050	400
0.070	200
0.080	150
0.090	120
0.100	100
0.125	64
0.180	30

By using the figures in the second column in the comparison method no calculation is involved in the grain size estimations.

Arguments in favor of diameter as the unit for grain size reference:

1. A smaller number indicates smaller grains, whereas in the area reference scheme the numbers are larger as the grain size decreases.

2. The diameter method probably permits of a better mental conception of the size of a single grain.

The writer is in favor of area as the basis for grain size reference and the use of the sq. mm. as the unit. In most useful metals the number of grains per sq. mm. would be a whole number and not so large a number as to become burdensome. The finest grained sample I have examined showed 80,000 grains per sq. mm. All of Mr. Miller's standards fall between 30 and 1600 grains per sq. mm. If grain size determinations are desired on exceptionally coarse grained samples the unit can readily be changed to sq. cm. by multiplying the number of grains per sq. mm. by 100.

Case School of Applied Science,
Cleveland, Ohio.

[2] The intercept method has been proved to be very inaccurate.

Annual Meeting of Chemists' Club

The annual meeting of the resident members of the Chemists' Club, New York City, for the election of officers and the transaction of other business, will be held on Wednesday, May 2 at 8 p. m. Interesting announcements will be made and refreshments and entertainment will be provided.

The Japanese Chemical Industry

New Enterprises Started in Japan Since the Outbreak of the War*

By PROFESSOR DR. H. NISHIDA

The great war has given the Japanese chemical industries a good opportunity for development. The following new enterprises, as reported by the Japanese Department of Agriculture and Commerce, are most important.

1. ARTIFICIAL DYESTUFFS

Until the war stopped importations from Europe, there was no artificial dyestuffs factory in Japan, with the exception of some pigment factories. The total amount of importations represents, therefore, directly the total demand of Japan. The figures of importations per year are as follows:

	Lb.
Aniline and alizarine colors	10,185,185
Artificial indigo	1,851,852
Total	12,037,037
Total price	$4,000,000

As a result of cutting off this large amount of importations, chiefly from Germany, the Japanese dyestuff market has been extremely excited, with a very large rise of prices.

At the same time, a great many dyestuff factories have been established, the largest of which is The Nippon-Senryo-Seizo-Kabushiki Kwaisha (meaning the Japanese Dyestuff Manufacturing Co.). This is specially encouraged by Government protection. Most of the new plants have been short of capital, and have also suffered seriously from the lack of good chemical experts; for these reasons most have recently been closed down. On the other hand, the Tokyo Gas Company and the Mitsui Mining Company have been most successful comparatively and have placed their product on the market. As aniline oil and aniline salt were easiest to make, overproductions of these products has come about, beyond the home demand of Japan.

Among all dyestuffs, most attention has been paid to the sulphur dyestuffs on account of their ease of production. "Some makers used every organic waste for the raw material as that stage of the manufacture of 'Cachon de Laval,' the first member of the sulphur colors. Some others have used aromatic compound for the raw material, and got the final success, still continuing the production of the black and brown sulphur colors, although they do not care much about the purification of the product which seems to be quite unknown to those chemists."

The largest company, mentioned before, The Nippon-Senryo-Seizo-Kabushiki-Kwaisha (capital $4,000,000), is now extremely busy finishing its equipment in order to start manufacturing in spring, 1917. When this company will begin to place its own products on our market the Japanese dye industry will be quite independent of foreign dyestuffs. But there are some who are doubtful and expect only a few colors to be placed on the market. When peace will be re-established the dyestuff-making industry in Japan will be certainly one of the most noticeable achievements of the period of war.

2. MEDICALS

Of medicals there are a great many varieties. The difficulty and complexity of manufacturing them have rendered the sound development of this industry difficult. Nearly all pure drugs have been imported in the past to Japan from Germany. Furthermore, most Japanese physicians have been trained in German universities and they have been accustomed to use the German medicals as the best and most necessary source of their recipes. Just as in the case of dyestuffs, the Japanese government has decided to protect the development of a drug industry in Japan. It has instructed The Sanitary Examination Establishment in Tokyo and Osaka to try to manufacture the more important medicals. Up to now these two stations have certainly been successful in actually making morphine-hydrochloride, bisalcycilic acid, carbolic acid, bismuth, atoropin sulphate and bi-compound, creosote, chloroform, codein phosphate, guaiacol, heroin-hydrochlorate, tannic acid and gallic acid, etc.

3. WOOD-DISTILLATION BY-PRODUCTS

Acetic Acid.—Since the new tariff went into force in 1911, the manufacture of acetic acid in Japan has obtained a very satisfactory position. By and by the Japanese home product has become of excellent purity and importations have almost ceased. As a result of the demand for it the price of acetic acid has increased to more than four times the normal price, and suddenly a quick increase of the capacity of production has become necessary. This has made it possible to export the products to the Oriental market as well as to England, the exports amounting to 1,468,333 lbs. in 1915, while the home demand of Japan was 1,984,127 lbs.

Calcium Acetate.—A great deal of acetate of lime, the raw material of acetic acid, has been imported to Japan from America, the importations amounting to 8,994,710 lbs. or more ($276,500). After the outbreak of the war there was not only an increase in the demand for acetic acid, but for acetone in America, with the result that exportations of acetate of lime from America were reduced. The importation into Japan stopped in June, 1915, and the market price has increased to as much as three times the normal price. After this time, however, nearly all charcoal-makers entered into the manufacture of crude acetate of lime as a by-product, and now the price is becoming more moderate.

Formalin.—As the sole antiseptic agent in silk-sericulture, much formalin has been imported from America and Germany (1,000,000 lbs. annually). In Japan since 1911, from 26,000 to 35,000 lbs. have been monthly produced. After the outbreak of the war a considerable amount was still imported for a while. But gradually the supply became deficient and finally the Japanese government determined to protect the home industry. Under these circumstances the firm of Toyo-Yakuhin & Co. (meaning Oriental Medicament-Manufacturing Co.) was established for an annual production of 1,500,000 lbs. of formalin.

Methyl-alcohol.—Methyl-alcohol, the raw material of formalin, was produced in Japan only in an amount of about 300,000 lbs., which amount was always insufficient for 400,000 lbs. formalin. Recently the process of its manufacture has been improved and the output is said to have remarkably increased.

4. GLYCERINE

Formerly Japan imported about 1,000 tons of glycerine annually from England, America and Germany, while at home about 760 tons were produced. On the other hand, the demand for military and technical purposes increased very materially, and when after the outbreak of the war the export of glycerine was strictly forbidden from all belligerent countries, the price in Japan increased to 3 or 4 times the normal price.

As a result new plants for manufacturing glycerine

*From the first issue of *The Kwagaku Kogei (The Chemical Technology)*, "a monthly journal of chemistry and chemical industry," edited by Prof. Dr. H. Nishida. The first issue contains 106 text pages, of which four pages are printed in English and 102 pages in Japanese. The figures of cost in the original article are given in yen (1 yen = 0.498 dollar). In converting the yens to dollars, 1 dollar has been assumed to equal 2 yens.

were established, among which the Nippon Glycerine-Kogyo Company (capital $1,500,000) was formed under the protection of the Japanese government. This company has a plant capacity of 500 tons of purified glycerine, which will be soon increased to 1000 tons output.

5. GLASS

Exportations from Japan to India and Australia have been very successful, and more orders are arriving from all parts of the Oceanian countries and even from England. Among them, Indian bracelet as well as glass beads, medical bottles, toilet bottles, lamps, cups, dishes are in especially great demand. Japanese glass manufacturers have increased their capitalizations and equipments.

The home demand for plate glass in Japan has increased recently to as much as 500,000 cases, but as imports from Belgium, England and Germany have absolutely stopped, the price has gone up rapidly. The only maker of sheet glass in Japan, the Asahi-Glass Manufacturing Company, has quickly increased its capacity, but the demand from abroad has also increased. China, Australia, India, Oceanian countries, South America are new trade markets for Japanese sheet glass. The said company is now busy preparing further extensions for the production of 700,000 cases annually and for the home production of the soda-ash, which is a most important raw material for the glass. Thick plate glass is now being made on an experimental scale by the Asahi Glass Manufacturing Company and by the Union Glass Co. The results obtained are said to have been very good.

5A. CELLULOID

Celluloid manufacturing in Japan had a very miserable experience until the end of 1913. There was overproduction by the two big factories, the output being greater than the Japanese home demand and only a few novelty articles being exported. Since the outbreak of the war, the Nippon Celluloid and Artificial Silk Co., Aboshi, has given up the manufacture of celluloid and has begun to make guncotton for Russia. At the same time exports of celluloid from Germany diminished considerably, while the demand for celluloid sheets quickly increased.

The only large celluloid manufacturer in Japan at the present time, the Sakai-Celluloid Co., is now extremely busy exporting its products to England, France, Russia, America, Australia, India, South Sea Islands, China and other countries. The increase in the manufacturing capacity of this company has not been sufficient to meet the demand.

The most important novelty articles of celluloid are household tools, combs, brushes, toys, "hangings," etc., $1,500,000 worth of these were manufactured in Japan in 1915, which is over twice the amount of the preceding year.

6. PAPERS.

Even before the war the Japanese paper industry had an enormous development. The Japanese home production of printing paper, writing paper, drawing paper, packing paper, amounted to 167,000 tons in 1913. Still better kinds of printing paper, drawing paper, writing paper were imported to the extent of about 37,000 tons. The outbreak of the war cut off these imports and the demand for paper in the Chinese market produced most flourishing times for every Japanese paper mill. Successive extensions of the mills were carried out and about 210,000 tons are said to have been the output during 1915.

Furthermore, the export of paper from Japan has also increased about three times. The manufacture of filter paper, which was not manufactured in Japan, has recently been started at Kochi.

It has lately become the practice in Japan to mix chemical wood pulp with Japanese best fibres. The sudden increase of the price of the raw materials has seriously affected the small paper makers. But by and by they are going to recover their fortune.

7. PULP.

Japan's annual demand of wood pulp is said to be about 120,000 tons, one-third of which used to be imported from Germany and Sweden. As this importation has stopped, the price has awfully increased. On the other hand, the price of paper at the time of the outbreak of the war was rather low, so that most paper mills using wood pulp have suffered greatly.

Of the total demand, about 60,000 tons are ground pulp, the rest being sulphite pulp. Of the former Japan does not want any importation, while of the latter she still wants to import about 40,000 tons. Lately many wood pulp mills at home have increased their capacity, so that after peace will be reestablished Japan will no more have any difficulties in the production of the desired amount of pulp.

8. PHOSPHORUS.

Japan's home demand of phosphorus has been 7000 cases (each of 100 lb.) These have been imported from France, England and Germany, 60 per cent being red phosphorus, 40 per cent yellow phosphorus. Before the war Japan had only two phosphorus factories, the Denro-Kogyo Co. (meaning Electric Furnace Co.) and the Fuji-Denkwa Co. (meaning Fuji Electro-Chemical Co.), both in the Shizuoka district. The output of these two factories were only 17 per cent of the total importation, so that match manufacturers got scared when war was declared.

The price was also enormously raised, to about $250 (5.5 times the normal price) per case of red phosphorus, and $200 (6 times the normal price) for yellow phosphorus.

This resulted in big extension of the above mentioned companies. The Denro-Kogyo Co. was amalgamated with the Nippon-Kwagaku-Kogyo Co. (meaning the Nippon Chemical Industry Co.), and the other company erected branch stations. At the same time a new company, the Tokyo-Denkwa-Kogyo Co. (meaning Tokyo Electro-Chemical Co.), was formed. The total output has thus reached 3700 cases, which is still less than half of the total home demand. So they are said to have made further extensions quite recently. At present the raw phosphorus ore is at an extraordinary price, but the price of the manufactured phosphorus also is high. Nevertheless, after peace is restored, the management of these plants will require most careful attention.

9. POTASSIUM CHLORATE.

Formerly the annual demand in Japan was 4000 tons, of which 1000 tons were made in Japan and 3000 tons were imported. After the outbreak of the war the export of matches has still continued in good condition notwithstanding the shutting off of the importations of chlorate of potassium from Germany, France, England and Switzerland. The price of this raw material once reached $90 per barrel (112 lb.), while the former price was only $8. At present a great many plants have been established for this purpose, and old factories have increased their capacity, and still the activity continues. There is ground for pessimistic fears as to an overproduction in the near future.

Oxidation and Reduction in Physical Chemistry—Consistency of Terms and Conceptions

By Carl Hering

In the Dec. 1 issue of this journal, page 649, the writer pointed out the inadequacy and inconsistency of some chemical terms which give rise to confusion, and suggested some reforms and remedies which would clarify matters and would lead to consistency and to concordant results. The purpose of the present article is to show that certain disputed and discordant conceptions in physical chemistry concerning oxidation and reduction can be systematized and brought into complete concordance when they are consistently interpreted.

The kind of chemical reactions commonly called reduction and oxidation, which are the direct opposites of each other, would embrace all the primary electrochemical reactions, and no doubt many purely chemical ones also, if the scope of these terms were applied more consistently to all the physical processes which are of identically the same nature, by extending their application in some ways and limiting them in others, instead of as at present limiting them by looseness of expressions and meanings to only particular ones of what are physically the same processes, and inconsistently applying them to others; this was touched upon in the previous article. The adoption of these more consistent and systematized meanings and conceptions would greatly simplify the study of the subject by students and cannot fail being of assistance or at least of interest to the professional electrochemist or chemist; it surely leads to clearness by avoiding ambiguities. Science is defined as classified knowledge—that is, knowledge which has been arranged in an orderly and systematic way; this systematizing of the scope of these terms would help to make order.

Reduction and oxidation being admittedly physically the same process, differing only in their sign or direction, and the processes terminating at the cathode and anode being also direct opposites though the same in kind, it follows that when it is said that the hydrogen which is set free from water at the cathode has been *reduced*, the oxygen set free at the anode must necessarily be said to have been *oxidized*, in order to be consistent; it would in fact be not only looseness but even physically wrong to say that the oxygen had thereby been reduced. To call it oxidation is not common practice to-day, but consistency and systematizing demand that the meaning of this term should be broadened to include all the processes which are the direct opposites of reduction. This consistency simplifies the conceptions of these processes and systematizes them, as will be shown below. That the oxygen has thereby been "oxidized" is not irrational, as its oxidizing action has then been increased, free oxygen having a stronger oxidizing power than when combined.

Similarly, when a metal combines with free oxygen it is correctly said to be oxidized, but the oxygen itself must necessarily be said to have been reduced in that process. This also is not common practice to-day, but consistency and systematizing demand this broadening of the term reduction in preference to introducing a new term. The oxidizing power of the oxygen has thereby been reduced.

Hence in general when two elements combine or are separated by processes ordinarily termed oxidation and reduction, the process defined with respect to one of them must always be the exact reverse of the process defined with respect to the other. Thus when H_2 and S combine, the H is being oxidized and the S is in fact being reduced to a lower degree even than free S; and when again separated the reverse is true. This, of course, applies likewise to combinations of other elements than oxygen and to radicals like SO_4.

In a general sense to aid the student, it may be said that oxidation generally consists in combining two or more elements to form a compound, or mathematically expressed, in the chemical addition of an element to another, while reduction, the reverse process, generally consists in separating them again, or mathematically expressed, in the chemical subtraction of an element from another. Physically, therefore, oxidation is in general of an additive nature or a gaining, while reduction is of a subtractive nature or a loss. This, however, is only a "guide to the memory" to what follows below, for it is evident that when H and O, for instance, are freed by separation (subtraction), the H being thereby reduced, the O must be said to be oxidized, as explained above; but, as will be shown below, this oxidation consists really in the addition of valence, and according to the writer's view an addition of electric charges, and is additive for those reasons.

The same is true of the bonds; reduction implies in a general way a reduction or loss of bonds, a breaking of them, and oxidation a gain of them or a making of them. But this again is only a general guide to the memory, for in the "oxidation" of oxygen by freeing it from H_2O there is a loss of the bond, though this loss is really the result of an *addition* to or an increase of a negative valence; thus the addition of 2 to —2 equals zero—that is, nothing—a free element having no bonds and therefore no valence while in that state. An estate owing $10,000 is worth nothing after $10,000 has been added to it.

All electrochemical oxidations and reductions consist in the changing of the valences, and therefore result in the making and breaking of chemical bonds; it can be shown that electrolytic reductions are always a reduction of the valences, while oxidations are always an increase of the valences. Bonds and valences are therefore closely allied, though they should not be considered the same thing, as is done by some authors, because the number of bonds depends not only on the valence, but also on the number of atoms; thus in Na_2SO_4 the valence of Na is 1 and of O is 2, but the Na has two bonds and the O has eight.

All bonds being positive with respect to one element and negative with respect to the other to which it is bonded, it necessarily follows that valences must have + and — signs also, and as a free element has no bonds, its valence must of course then be zero. This was explained more fully in the earlier article cited above. Compounds which are not ionized have no free charges, which means that their positive and negative charges are equal, and it is supposed that the force holding the elements together is caused in some way by the attraction of these charges to each other.

Chemical reduction being therefore always accompanied by a *loss* of valence and in a general way by a *loss* of bonds and a *loss* of a companion element, and oxidation by a *gain* of valence, and in a general way by a *gain* of bonds and a *gain* of a companion element, consistency would indicate that probably modern theories would show that reduction also means a *loss* of negative electric charges and oxidation a *gain*. Some writers, however, claim that it is the reverse of this, which would be an unfortunate break in consistency if it were really definitely proved by facts, as distinguished from arguments involving definitions about which there is doubt or disagreement. It would, in fact, be so desirable, not only for the benefit of the student but also to

systematize our conceptions, to establish this consistency, that there would seem to be justification for defining terms now having a doubtful meaning in such a way as to bring about this much desired consistency and concordance, assuming, of course, that the result is not at variance with the true facts, and the writer has not been able to obtain from the advocates of the "prevalent" view any positive proof that oxidation is physically really a loss of negative electrons. Until the latter has been established physically as distinguished from deductions from ill-defined or incomplete conceptions, the following analysis and strict definitions are believed to show that the desired concordance seems to be true, and could therefore be used until the contrary has been definitely established by proof.

It is known and apparently not disputed that at least with electrolytes every unit of valence represents a charge of one faraday (96,494 coulombs or 26.80 amperehours) and that reduction is a loss of valence, hence a loss of these charges, while oxidation is a gain of valence or charges. So far, therefore, the gain and loss of charges are consistent with the gain and loss in other respects. This does not specify, however, whether these charges are positive or negative.

According to our older conceptions it is the positive electricity which flows in the direction of the conventional arrow, hence a loss of a charge means that it was a positive one. The older conception also states that the cation is reduced at the cathode, to which it gives off its positive charge, which then passes off as the electric current, after which the freed element is neutral again. The current enters the electrolyte at the anode, from which the positive charges are received by the anions, thereby neutralizing their negative charges and freeing them. Hence, according to these older and simpler conceptions, reduction is accompanied by a loss of charge and oxidation by a gain; this is consistent with the above.

But the modern electron theory says that it is the negative electrons which move in the opposite direction, hence it follows that a loss of a charge would mean that it was a negative one. And the modern dissociation theory states that the dissociation of a compound into its ions occurs while it is being dissolved, hence before any current is applied, it therefore does not occur at the electrodes as was formerly believed.

Solid, electrically neutral NaCl, for instance, when dissolved in water, dissociates in part at once, without a current, into Na ions and Cl ions, hence the actual separation occurs then; the bond which combined them is thereby broken, it then no longer exists, as these ions then are separate molecules. The very word "dissociation" means separation into component parts; by saying that steam is dissociated by a high temperature is meant separating it into H_2 and O; that is, breaking the bond.

Oxidation and reduction considered physically involve the making and breaking of bonds, hence it is at the moment when these are made or broken that the process of oxidation and reduction really takes place. Dissociation is a breaking of these bonds, hence the actual reduction of the cation occurs during the dissociation process, and as was shown above, while one ion of a compound is being reduced, the other, undergoing the reverse process, must be said to be undergoing oxidation, in the broad sense that it is the reverse of reduction; hence true oxidation also occurs during dissociation.

It is true that the ions produced by dissociation are then not yet completely freed; the Na and Cl in dissociated NaCl are not yet free Na and free Cl; they are still held by their charges in some way which is perhaps not yet clearly understood; but it is sure that they at least have had their chemical union broken, which is what the word dissociation means, and it is this part of the whole freeing process which, to be consistent, must be called the real reduction process; chemical reduction often does not mean complete freeing, as, for instance, in reducing ferric to ferrous salts, yet it is physically and by definition a true reduction; freeing an element is therefore not an essential attribute of reduction; reduction is only a step toward freeing an element. Oxidation can also free an element, as was explained above, but freeing it is not an essential attribute of oxidation.

According to the now generally accepted dissociation theory, therefore, and using the words reduction and oxidation in what seems to be their rational and consistent sense, the ions are reduced and oxidized during dissociation, and it is only after this and not before that the cations have the so-called free positive charges and the anions the free negative charges; it is important to note that it is only the dissociated elements and not those which are still combined that have these charges—those that are still combined are neutral. It is said, for instance, in a colloquial way, when free H has been oxidized by free Cl to HCl, that it then has a positive charge, because it is generally so marked. This, in the writer's opinion, is a misinterpretation of what appear to be the real facts, and leads to great confusion. The H in HCl, which has a positive charge, is only that fractional part of the total which has *subsequently* been dissociated again from the HCl, and which in thus being reduced again has lost a negative charge; the H which is left in the solid HCl, or that which still remains combined as HCl in the dissolved though undissociated salt, has no free charge.

According to J. J. Thomson, the father of the electronic theory, "An atom plus an electron is a monovalent anion; an atom minus an electron, a monovalent cation." As the cation is that ion which *has been* reduced by the dissociation, and as the word electron here means negative electricity, it follows again that reduction is accompanied by a loss of negative electrons and oxidation by a gain.

Hence during the real process of reduction the cations must have *lost* negative charges because they are known to have free positive charges left, and during the accompanying real process of oxidation the anions must have *gained* negative charges, because they are known to have free negative charges thereafter. This, therefore, again agrees with what was said above concerning loss and gain of valence, bonds and companion elements, thereby showing perfect consistency and concordance throughout.

It is said that the iron in ferric sulphate, for instance, has three positive charges, often indicated by three + signs over it, and that in ferrous sulphate it has two positive charges; in a colloquial way it is said that *therefore* when ferric iron is reduced to ferrous it has gained a negative charge, hence that *reduction* is a *gain* of negative charges, the contrary to the above. This deduction, however, the writer maintains is incorrect; the iron thus marked in the ferric salt represents that which *has been* dissociated to iron from its compound, and therefore *has been* reduced, during which reduction it has *lost* three negative charges, as it has three positive ones left; before this reduction by dissociation—that is, while still combined—it had no free charges, hence the very fact that it now has three shows that it *has been* reduced.

In the writer's opinion it is therefore not correct to say (as has been done by some authors) that the iron in the ferric solution, in which it is marked as having

three + charges, has gained a negative charge (lost a positive one) by being reduced to the ferrous state, in which it is marked as having only two + charges. In formulas thus marked both are now the same reduced ionized iron and therefore are alike as such, both having been reduced to the same unoxidized iron from their respective combinations by dissociation, which is assumed to have taken place then or they would have no charges; neither can now be said to have been reduced or oxidized from the other; the charges marked on them represent their *previous* history as it were, and not their present state of oxidation, the one having lost three negative charges when it was dissociated (reduced) to iron from the ferric salt, and the other having lost two negative charges when it was dissociated (reduced) to iron from the ferrous salt.

While both of these ions are therefore alike in being ionized (reduced) iron, there is still left the difference that the one carries three positive charges and the other two; but this difference is a result of the real reduction (breaking of the bonds) as explained above, and any subsequent process like the completion of the freeing by neutralizing these charges with a current is not a part of the real reduction when that term is consistently defined; it is physically something else than reduction, to which perhaps no name has yet been given; it might properly be called the neutralization or freeing of the charges, but not oxidation and reduction. If in a colloquial way this final freeing of the dissociated ions has been referred to as the real reduction and oxidation (and this is implied or even directly stated in some textbooks), it is surely inconsistent and therefore, in the opinion of the writer, should be corrected. When the iron in a ferric solution has been reduced to ferrous, a real and physically perfect process of reduction, complete in itself, has taken place, of which the final freeing of this iron is not an essential part.

The controversy may be said to lie in the definition of the term reduction; if it is defined consistently as always applying to that physical process in which the bond joining two elements is broken, as recommended in this article, then everything is brought into complete concordance and agreement, but if it is defined as applying sometimes to this and sometimes to the process of setting free an element which has already been separated from its combination, or dissociated as it is more frequently called, then looseness of meaning, discordance, inconsistency, confusion and lack of uniformity result it is then like a series of gear wheels which should all mesh together for a common end, but in which one of the wheels is "out of gear" or "out of mesh" with all of the others.

For a long while it satisfied chemists to represent water as HO, and it satisfied the people to say that the sun moved around the earth; but to-day these and many other conceptions which were "universally accepted" in former times have been discarded for better ones.

Even if a direct physical demonstration, as distinguished from an argument based on loose definitions, would show beyond question that oxidation is always accompanied by a loss of negative electrons, yet to bring about concordance which is so helpful to the student, and in view of the fact that the + and — signs and the conventional arrow are still in common use, indicating a flow of current from + to —, the writer would still advocate saying that oxidation is a "gain of charges" (+ charges in that case) and adding the explanation which must to-day also be added in numerous other cases, that it is really the negative electrons which move in the reverse direction, just as we still say that the sun "rises" in the east, with an explanation when necessary. Electrolytic reduction would then have to be explained as taking place at the cathode and not during dissociation, though this would involve unfortunate inconsistencies which tend to confuse the student.

As the term "reduction" implies a subtraction, hence a loss, it is an appropriate one to be applied to a loss of valence, charge, bonds and companion elements. But the term "oxidation" is not an appropriate one for the reverse and is acknowledged to be inconsistent in that it is applied to combinations with other elements than oxygen. It is for this as well as for the additive features given above that the writer favors the new word "adduction" for the exact reverse of reduction. Since the former article was published, the writer found that this term had already been suggested for similar reasons by Dr. M. L. Hamlin in an article by Nelson and Falk, *Journal* American Chemical Society 35, December, 1913, page 1812.

Philadelphia, Pa.

Manufacture of Pig Iron in the Electric Furnace at Domnarfvet, Sweden

The large Helfenstein electric furnace at Domnarfvet, Sweden, which was started in May, 1913, and a new one under construction, are the subject of a discussion in (London) *Iron and Coal Trades Review*, Feb. 23, 1917. A review of an article on these furnaces in *Stahl und Eisen*, by Dr. Max Oesterreich of Vienna, forms the basis of the discussion, which is as follows:

"The original furnace used three-phase current and had three top electrodes. It was inspected in 1914 by Dr. A. Stansfield of the Canadian Department of Mines, and was stated to be still in the experimental stage at that time and very little information was given out. The article by Dr. Oesterreich gives the results of the working with soft charcoal for a week in June, 1913, when certain breakdowns were occurring.

"The maximum output in twenty-four hours was 65 tons, the monthly total varying between 1000 and 1500 tons of pig iron, "according to the available amount of electric energy and the quality of the ores." For a longer period of working with charcoal as a reducing agent, the following average consumptions are given per ton of pig iron:

Energy consumed (60 per cent ore), 2170 kw.-hr.
Charcoal (70 per cent C.), 380 kg.
Electrodes, 5 kg.

When working experimentally with coke the average rates of consumption per ton of pig iron were as follows:

Energy consumed, 2600 to 2700 kw.-hr.
Coke, 310 to 330 kg.
Electrodes, 4 kg.

"At the same time the author makes the statement that the consumption of electrodes has now been reduced to 2 kg. per ton of pig iron, a figure, we are told, so low that it has not yet been beaten by any other furnace.

"The trial working with coke did not last long enough to enable one to form a definite opinion, but the results were, nevertheless, encouraging, so much so that a Helfenstein electric low-shaft furnace is now in course of construction in Norway, and is to start work in 1917. In the construction of this plant special attention is being paid to the rational production and utilization of the furnace gases. The new plant is to demonstrate the superiority of electric smelting of iron ores over the old blast furnaces, and not the high-shaft electric furnace, in all situations where electric energy is cheap and coke is expensive. According to the author, the hp.-year yields an output of 2.4 tons of pig iron with coke as a reducing agent in the electric furnace, and there is a saving of 1.68 tons of coke per hp.-year compared with

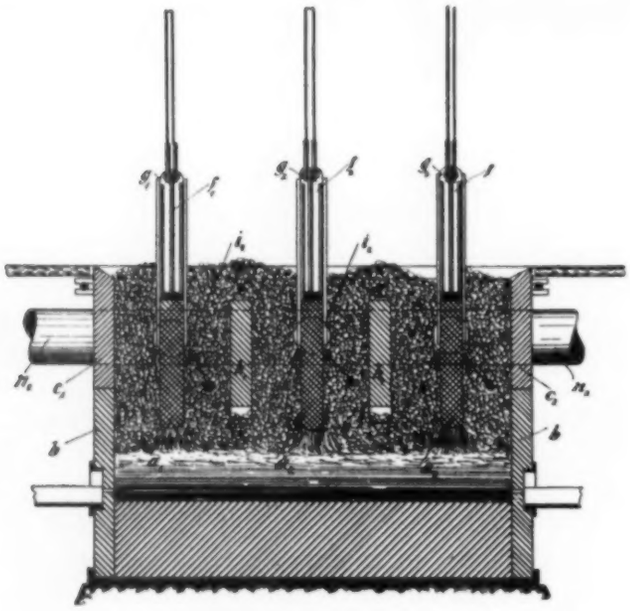


FIG. 1—LONGITUDINAL SECTION OF MULTIPLE-HEARTH FURNACE

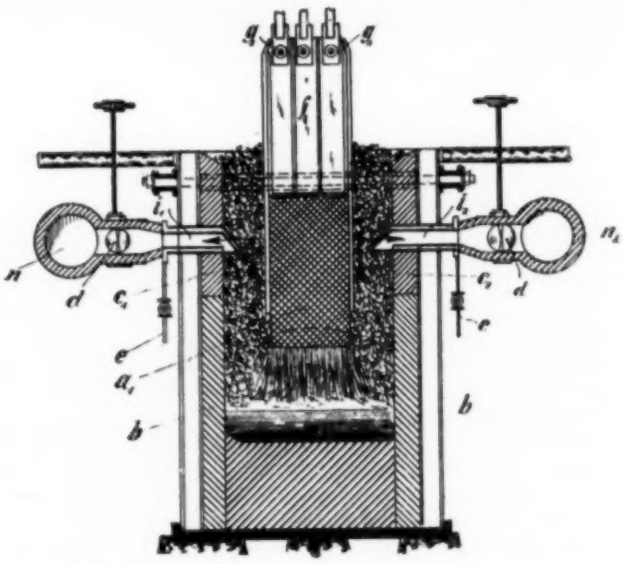


FIG. 2—CROSS SECTION THROUGH PLANE OF ONE ELECTRODE

ordinary blast-furnace working. Hence, wherever the hp.-year costs less than 1.68 tons of coke, an electric furnace would be preferable to an ordinary blast furnace from the point of view of working expenses. In checking the author's figures, it will be found that 2.4 tons of pig iron smelted in the electric furnace require 768 kg. of coke, which added to the saving of 1.68 tons, represents a consumption of 2.448 tons of coke to produce 2.4 tons of pig iron in the ordinary blast furnace, which is a fair figure, considering the high grade of the ore. The cost of the electrodes has been purposely disregarded, as it should be more than compensated by the saving of interest on the reduction in the first cost of the installation, and by savings in other directions.

"The building for housing the Helfenstein furnace at Domnarfvet has been made 8 metres (26 ft. 3 in.) higher than would have been necessary, as it is to accommodate also a Grönwall furnace. For a low-shaft furnace alone a height of 16 metres (52 ft. 6 in.), including the depth of the bins for storing materials, would have been ample. The furnace can be tapped on either side. Besides the large furnace a smaller one of 400 to 500-hp., constructed as a low-shaft furnace on the same principle, is also used for experimentaing and testing purposes.

"The main new fact now told is that of the seven men formerly in attendance on (what was intended to be) a 10,000-hp. furnace (three for tapping, one attending to the regulators, and three chargers), two of the last mentioned can now be spared, since cranes have been provided for charging the furnace, which is being worked with a mixture of charcoal and coke at a reduced voltage developing 5500 hp. only as a consequence."

The original article of Dr. Oesterreich contained seven illustrations, but as *Stahl und Eisen* is not available in this country, and none was included in the above review, we are unable to reproduce any of them.

A patent on one type of furnace has, however, just been issued in this country to Mr. Alois Helfenstein (1,223,278, April 17, 1917), and assigned by him to the Union Carbide Company. The Helfenstein furnace was first used for calcium carbide and ferrosilicon, but was later (starting in 1912) adapted to iron ores. The furnace has been described in our Vol. VIII, p. 46 (1910) and Vol. X, p. 658 (1912) by Dr. R. Taussig, and also in abstracts of patents in various issues of this journal.

The present patent was applied for in June, 1914, and describes a multiple-hearth electric furnace, the chief feature of which is the common charging column for all electrodes, which does away with separate bells and hoppers. A longitudinal section of the furnace is shown in Fig. 1 and an end section in Fig. 2.

It is stated that in furnaces intended for large outputs the arrangement of a charging bell and hopper around every electrode interferes with the efficient working of the furnace. Consequently the electrodes are served by a common charging column. This also makes possible a more effective disposal of the furnace gases. In the figures a_1, a_2, a_3 are three electrodes, b is the common reaction shaft and c_1, c_2 is the common charging shaft. Between every two reaction hearths is arranged a partition wall h_1, or h_2, consisting of a fireproof girth. These are to prevent current leakage from one electrode to the other. The gas is drawn off through tubes i_1, i_2, provided with water jackets and regulated by valves.

"The collected gases pass over into the conduits n_1 n_2, which, according to the process, may serve also as combustion or as condensation pipes, or they may be constructed in such a manner that the gases are conducted away through the same without being burned, or that they are burned in the presence of or together with a suitable supply of air.

"The furnace is intended especially for the production of heavy metals, alloys having iron as a component and volatile metals and their oxides, such as zinc.

"The height of the charging shaft extension depends, of course, upon the process, especially, however, upon whether or not pulverulent or granulated material is made use of.

"The height should also be such as is necessary for packing the openings of the gas outlet conduits, and further to allow a certain length necessary for some spare material, according to the manner of charging the charging shaft. If, for instance, iron ores are to be reduced, an electrode of 2 meters' length will be completely covered by the charge and also the electrode socket will get down in course of time into the charge, as the electrode is consumed during the course of the process. If, however, the height of the normal working shaft of an electric raw iron furnace amounts, for instance, to about 1.5-2 meters, the height of the charging shaft forming the extension of the former will amount to about 1.5-3 meters or even more."

Synthetic Rubber

By Andrew H. King

When the great chemist, Bayer, completed his synthesis of indigo and placed his process on a commercial footing, the indigo planters received a rude shock. They had been content to let well enough alone. To them the old way was the best way. They wanted no theorists about. They were practical men. The methods were old, time-tried, and unalterable. When things didn't go right they blamed it on God. Needless to mention there were many instances when something went wrong. The variation in their product kept the dyers constantly on the jump. Indigo sold at a high price, and the business amounted to something like $25,000,000 annually.

It is no wonder that the planters felt secure. Indigo was a mysterious substance, could only be produced by natural means, and all the labor of the theorist was worse than useless. So they thought. Synthetic indigo was a man's task. It took Bayer fifteen years to determine its chemical constitution and to synthesize it. To render its production a commercial possibility twenty more years were required. The Badische Company spent millions of dollars. The first process, which started with toluene, was discarded because too little of this liquid was available. Finally, by accident, a way to convert naphthalene to phthalic acid was found, and another synthesis followed. Naphthalene is readily obtained from coal tar. It is consequently cheap, and the quantity is almost unlimited.

Synthetic indigo was soon in great favor. Its uniformity, its purity, and therefore its great strength made it much superior to the natural substance. It was cheap and increasing demand had but little effect on the price. Within a very short time natural indigo declined to almost a curiosity.

When the utilization of rubber became a business the demand for the crude gum sent the price up like a skyrocket. In 1910, which date may be taken as the beginning of modern rubber expansion, only 80,000 tons of crude rubber were produced. Of this quantity but 8000 tons were plantation grown. Seventy-two thousand tons were wild rubber, and as variable in quality as can be imagined.

Here was certainly a field for the synthetist. With the remarkable success of Bayer as an incentive, organic chemists all over the world went to work. Forgetting the great expenditure of time, energy and money that the conquest of indigo required, the world expected immediate results. When these were not forthcoming many said it could not be done. Even to-day the opinion of many rubber chemists is that synthetic rubber is only of theoretical and scientific interest.

This may all be true, but if so it is only because the men who laid the foundation of plantation rubber well knew the story of natural indigo, and availed themselves of the botanist. They met science with science. By 1915 their yearly production was 146,000 tons, as against 8000 tons in 1910. The ready demand for this rubber makes me wonder to what unknown figure this commodity would have risen if the old haphazard methods had not given way to science.

To date synthetic rubber has done remarkably well. The first step of any synthesis is to determine the structure of the material you wish to build up. Since rubber is a colloid its chemical structure is rather difficult to visualize. This has now been done with a reasonable degree of certainty. Various methods of synthesis have been developed, which while they are very expensive have merit in that they actually produce caoutchouc. There remains only the commercial production. Our friends the botanists are making this more difficult every year. Still we have hopes. It is my claim that not sufficient time has elapsed, not enough energy been given to the proposition to yet justify its discard as unworkable. It, therefore, behooves us, as American chemists, to give thoughtful consideration to the matter. As a preparedness measure a successful commercial synthesis of rubber would be invaluable.

The Structure of Caoutchouc

By caoutchouc is here meant the pure rubber hydrocarbon, differentiating it from rubber, which contains besides caoutchouc various resins, proteins, etc., all of which have a bearing on the commercial value of rubber.

The facts having the greatest bearing on this question may be listed as follows:

(1) Caoutchouc has been found to be a hydrocarbon having the empirical formula $(C_5H_8)_n$ or $(C_{10}H_{16})_n$.

(2) It readily forms a tetrabromide, $C_{10}H_{16}Br_4$.

(3) When combined with a maximum amount of sulfur (32 per cent) a compound $C_{10}H_{16}S_2$ is produced.

(4) If caoutchouc is but partially saturated with bromine, *i.e.*, only two atoms of bromine added on, but one atom of sulfur can be subsequently combined.

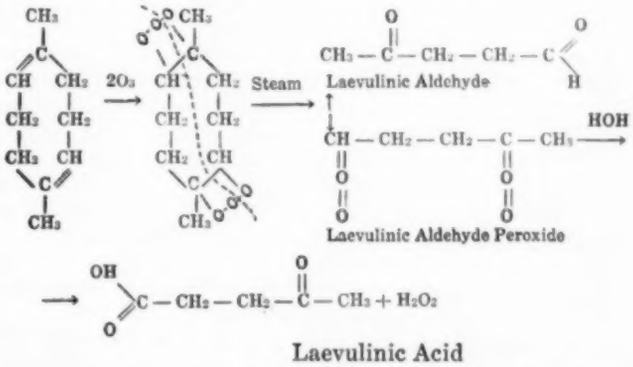
(5) When treated with ozone and ozonide $C_{10}H_{16}O_6$ is produced.

From the above it appears that caoutchouc is a hydrocarbon having two double bonds for every ten carbon atoms.

Harries[1] has attacked the problem from the standpoint of the ozonides and their hydrolysis products. He very carefully prepared the pure caoutchouc, dissolved it in chloroform, and passed ozone through the solution. In this way he obtained the ozonide, $C_{10}H_{16}O_6$.

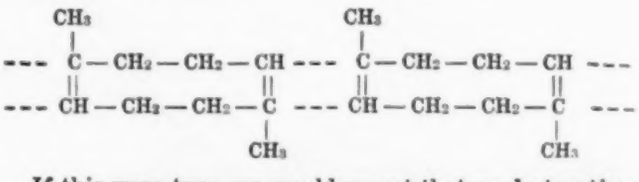
On treatment with steam this yielded laevulinic acid, laevulinic aldehyde, and hydrogen peroxide.

The simplest explanation of the above requires the assumption that caoutchouc is 1:5 dimethylcyclooctadiene. On treatment with ozone, a diozonide is formed which splits on hydrolysis to laevulinic aldehyde and laevulinic aldehyde peroxide, which is further hydrolized to laevulinic acid and hydrogen peroxide.



Laevulinic Acid

It will be noticed that the foregoing may be applied to a ring of any size. It is generally accepted that the caoutchouc molecule is very large. Harries originally considered that it was made up of a number of $C_{10}H_{16}$ nuclei, held together, according to Thiele's theory, by the partial valences of the double bonds.



If this were true, we would expect that on destructive distillation, simple dimethylcyclooctadiene would be ob-

[1]Ber. 1904, 37, 2708.

tained. This is, however, not the case, since by the most careful distillation under a vacuum the simplest substances obtained have at least 20 carbon atoms.

This and other reasons lead Pickels to suggest that instead of the eight-membered ring one of at least 32 carbon atoms would be more correct.

Harries[2] has lately retracted his original eight-membered ring theory, and now considers that the ring contains 20 carbon atoms. He has conclusively demonstrated that hydrolysis of the ozonide yields only laevulinic acid and laevulinic aldehyde. Therefore, the structure must be that of a ring. If it were a chain the oxidation products of the two end C_5H_8 groups would certainly be present.

It is the practice of organic chemists in studying a compound first to break it down, and if possible to identify the decomposition products. This done, they attempt to synthesize it from compounds whose structures and properties are known.

On dry distillation rubber yields a number of substances, among which is isoprene. This diolefine was first isolated and named by Grenville Williams in 1860.[3] Later, 1875, Gustave Bouchardat[4] undertook a detailed investigation of isoprene, and among other things he found that treatment with concentrated aqueous hydrochloric acid in the cold (0 deg. C.) and subsequent distillation, that a solid residue was obtained. This he found to possess "the elasticity and other properties of rubber itself." It dissolved in carbon bisulfide, and was precipitated by alcohol. On dry distillation he obtained the same products as are given by natural rubber under like treatment. This statement of his has been questioned by certain chemists on the ground that analytical methods were not highly developed in his day, and serious mistakes were possible.

Tilden in 1882[5] in a paper on "Hydrocarbons of the Formula $(C_5H_8)_n$," mentioned that isoprene was converted to rubber by the action of nitrosyl chloride. In 1892[6] in another paper he told of the spontaneous conversion of isoprene to rubber. A bottle of isoprene prepared from turpentine many years before was found to contain instead of a clear, limpid liquid, "a dense syrup, in which were floating several large masses of a solid of a yellowish color." He found the liquid acid to litmus, and accounted for the spontaneous polymerization by the hypothesis that a small quantity of acetic or formic acid had been produced by the oxidizing action of the air, and that the change had been brought about by this substance or substances.

Wallach[7] in 1885 stated that isoprene placed in a sealed tube and exposed to the action of light for a long time gave a product which on treatment with alcohol formed a tough mass resembling rubber, but becoming more or less hard on exposure to air.

The experiments of Tilden and Bouchardat were repeated by Weber,[8] who obtained 211 grams of caoutchouc from 300 grams of isoprene after keeping for nine months. This work was later checked by Pickels[9] and by A. Heinemann in 1907.

Late in 1909 certain samples of synthetic caoutchouc prepared by Fritz Hoffmann were sent by Duisberg to Harries for test. The latter was able by means of the hydrolysis of the ozonide to prove beyond a shadow of a doubt that the material was actually caoutchouc.

Harries[10] was unable to duplicate the experiments of Bouchardat and Tilden, and he held that these men, if they did produce rubber, were fortunate in having just the right conditions. He also calls attention to the fact that they did not prove sufficiently that they actually had caoutchouc. For, as Klages has pointed out, isoprene yields a number of substances on polymerization, many of which can be characterized as rubber-like, but which bear very little relation to rubber.

For some time past a more or less acrimonious argument has been in progress between certain English chemists, notably Perkin, Jr., and Germans, represented principally by Harries. The former hold Bouchardat and Tilden the discoverers of synthetic caoutchouc, and the latter claim that the honor belongs to Hoffmann.

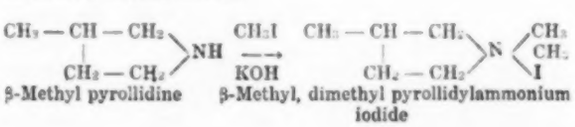
Now isoprene is a very peculiar substance, and is capable of existing in various degrees of purity. On polymerization it yields various products which differ principally in the number of (C_5H_8) groups in the aggregate. To produce rubber from isoprene the polymerizing conditions must be well regulated, all of which Hoffmann seems to have done. Regardless of whether Bouchardat, Tilden or Wallach did have rubber or not, they said they had, and certainly a work which supplies incentive to other investigators is not valueless.

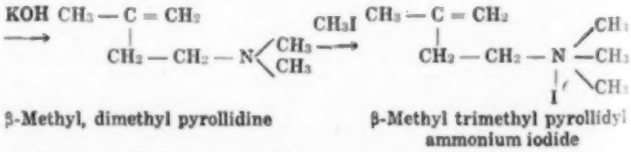
Science is international, a servant of world progress, and any attempt to classify an advance as strictly English or strictly German is not in keeping with the best interests of civilization.

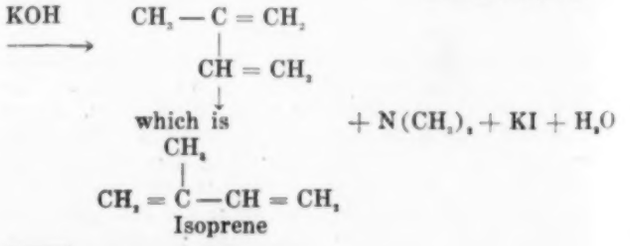
We have now demonstrated that natural caoutchouc is very probably a polymerization product of isoprene. Harries was able to show that Hoffmann's synthetic caoutchouc, which was made from isoprene, yielded on hydrolysis of the ozonide the same products as natural gum, namely, laevulinic acid and laevulinic aldehyde. Thus we know that caoutchouc is made up of (C_5H_8) groups, united in a ring. Upon the number of these groups in the ring is thought to depend the commercial value of the rubber.

Formulae

On analysis isoprene was shown to have the empirical formula C_5H_8. Tilden[11] as far back as 1882 considered it to be β—methylcrotonylene, $CH_3 = C(CH_3) - CH = CH_2$, but he made no experiments to bear out his theory. All the early investigators obtained their isoprene from natural sources. Bouchardat secured his from caoutchouc itself, and Tilden from turpentine. No one had produced isoprene by well defined chemical methods from a substance whose structure was known. In 1898 Euler[12] produced it from β methylpyrollidine by exhaustive methylation.

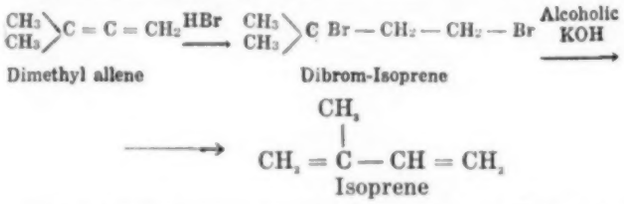




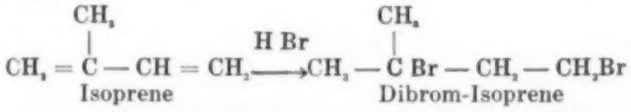


[2] J. Chem. Soc., 1915, A1253.
[3] Proc. Roy. Soc., 1860, 10, 516.
[4] Compt. rend., 1879, 89, 361 and 1117.
[5] Chem. News, 46, 220.
[6] Chem. News, 65, 265.
[7] Annalen, 227, 295.
[8] J. Soc. Chem. Ind., 1894, 13, 11.
[9] Trans. Chem. Soc., 1910, 97, 1085.
[10] Chem. Ztg., 34, 315.
[11] Chem. News, 46, 220
[12] J. prakt. Chem., 57, 132.

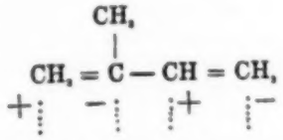
Ipatieff[13] also synthesized isoprene. He began with dimethyl-allene, added two molecules of hydrogen bromide, and subsequently removed them.



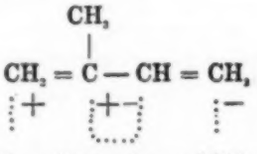
The dibromide mentioned above is identical with the one formed on treatment of isoprene with hydrobromic acid.



You will notice that isoprene contains the grouping C = C — C = C. This was called by Thiele a "Conjugated System." It would be expected that such a compound when treated with bromine would add on four atoms, one on each carbon, thus CH_2Br — $C(CH_3)Br$ —$CHBr$ — CH_2Br. This is, however, not the case, for only two atoms of bromine are added, and they go to the end carbons, forming a double bond in the center: CH_2Br — $C(CH_3)$ = CH — CH_2Br. Thiele's explanation of such phenomena is based upon his theory of "Partial Valences." It is imagined that two atoms when held together by a double bond, do not have the whole of their affinity used up, and that each possesses a slight excess of valency, to which the great additive power of unsaturated compound is attributed. Now, if we indicate the partial valences by dotted lines, and consider the carbon atoms of the chain as alternately charged with positive and negative forces, we may write isoprene

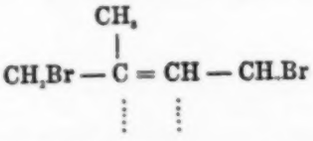


The partial valences of the two interior atoms neutralize one another so that we have

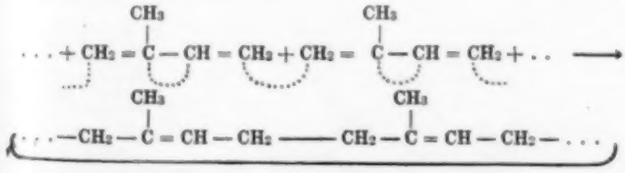


From this it is clear that when addition takes place, it can only occur at the end carbons, and a new double bond appears at the center.

This becomes intensely interesting and instructive,



when we try to visualize the manner in which isoprene is polymerized to caoutchouc. According to this theory,



[13] J. prak. Ch., 55, 4.

We now know that a relatively large number of isoprene groups linked together to form caoutchouc, so that we may write its formula:

This n we know to be something less than 40.

The Synthesis of Caoutchouc

It is now believed that any substance containing a conjugated system, C = C — C = C is capable of polymerization to a rubber-like substance. The hydrocarbons of most interest, and with which this is possible, are the following:

(1) Butadiene $CH_2 = CH - CH = CH_2$ known also as Erythrene, Divinyl, and Crotonylene. This substance when polymerized gives a caoutchouc which was called by Harries, Nor-caoutchouc, since a "Nor" substance is the synthetic methyl-free, mother substance of a series of bodies.

(2) Isoprene, α-methyl-butadiene, $CH_2 = (C(CH_3) - CH = CH_2$, is the parent substance of natural rubber.

(3) Piperlyene β-methyl-butadiene, $CH(CH_3) = CH - CH = CH_2$.

(4) Dipropylene or 2, 3, dimethyl-butadiene.

$$CH_2 = C(CH_3) - C(CH_3) = CH_2.$$

(5) 1, 4, tetra-methyl-butadiene.

$$C(CH_3)_2 = CH - CH = C(CH_3)_2.$$

One of the most serious difficulties in the way of a satisfactory synthetic caoutchouc is that of polymerization. As was previously related, isoprene and its homologues tend to polymerize to substances of higher molecular weight. This action does not by any means always produce rubber. It is very important that the right conditions as well as the correct catalyst be determined so as to give a high value for "n." If by any chance the right conditions are not maintained, or if some impurity is introduced, which poisons the catalyst, the polymerization product will be a dirty, sticky, resinous mess of no value whatsoever.

According to Harries,[14] natural caoutchouc exists in three type forms:

(1) Ordinary solid crude caoutchouc.

(2) Insoluble form.

(3) Oily.

All are mutually transformable. (3) goes to (1) slowly but spontaneously. (1) goes to (3) on warming in solution. The change from (1) to (2) or (2) to (1) is also spontaneous. (3) may be converted to (2) by acetic acid.

Artificial caoutchouc behaves in a similar manner. The purer it is the more readily does it pass into the insoluble form. The best yield is obtained from pure specimens of isoprene, irrespective of the method of preparation. The artificial caoutchouc must be kept in an atmosphere of carbon dioxide and protected from light, or oxidation is likely.

A brief review of some of the most important methods of bringing about polymerization is given below:

Auto-polymerization:

Elberfelder Farb., British Pat. 15,254, 1910, describes the following methods:

(1) Butadiene dissolved in benzole is heated ten hours at 150 deg. C. for a number of days.

(2) Butadiene condensed at a low temperature by means of ether and carbon dioxide is kept in an autoclave at 90 to 100 deg. C. for four days. In both cases the solvents, unreacted upon material and by-products, are distilled off in vacuo or by steam, and a rubber like mass remains.

[14] Ann., 383, 157-227.

Piperylene may be polymerized on long heating, fourteen days at 105 to 110 deg. C.

Conditions vary slightly for the various hydrocarbons, but in brief the process consists of heating them for a long time at a moderate temperature under pressure.

Various ozonides and peroxides have been added to catalyze the polymerization. The product so obtained is not overly valuable, as will be shown later on.

Acetic Acid:

Harries[15] directs that isoprene be heated with an equal volume of glacial acetic acid under pressure on a water bath during eight days. The yield varies widely, but is little affected by using different quantities of acetic acid, or by changes in the temperature. When only a few drops of acid are employed, it is necessary to distill the product under ordinary pressure, to remove the isoprene and its dimolecular polymerization product, and finally to distill at 105 deg. C. to remove any oily material. The residue is transparent, almost colorless, and closely resembles natural caoutchouc. When freshly prepared it is readily soluble in organic solvents, but loses this property on standing.

Caustic Soda:

French Pat. 417,170, 1910. Badische An. & Sod. Fab. Isoprene with the addition of 10 per cent of its weight of concentrated alcoholic soda is heated to 110 deg. C. under pressure for a sufficiently long time. After distilling off unconverted isoprene, the rubber is either dissolved in benzole and precipitated by alcohol, or is kneaded into a compact mass, from which the caustic is removed in the usual manner by washing.

Another method which finds application with 2, 3, Dimethylbutadiene, is to heat with 14 per cent caustic soda solution for 80 hours at 100 deg. C., purifying as above described.

Heating with Indifferent Material:

The Badische Company has found 2, 3, Dimethylbutadiene, that heating with an indifferent agent, as, for example, water, sodium chloride solution, alcohol, etc., that a better yield was obtained. Hydroxides of the alkaline earth metals and alkaline reacting salts are also beneficial.

Anaerobic Bacilli:

The possibility of the use of enzymes has not passed unrecognized. Gottschalk in 1907 proposed to utilize the action of bacteria on hydrocarbons.

British Pat. 15,299, 1909, covers the treatment of isoprene or its homologues with anaerobic bacilli obtained from natural rubber or latex.

By the Use of Sodium:

The discovery of this reagent was made almost simultaneously in England by Matthews,[16] and in Germany by Harries.[17]

The method described by Harries is as follows:

Pure isoprene and 0.02 to 5 parts of sodium wire are heated to 60 deg. C. for 50 hours, and then purified by the usual methods. The product when freshly prepared is easily soluble, and may be vulcanized quite readily. The yield is almost quantitative. The low temperature used is a decided advantage.

For other hydrocarbons the temperature and time of heating are varied somewhat, but the basic principal remains the same.

It is sometimes an advantage to prepare sodium caoutchouc in the presence of carbon dioxide.[18] The product so obtained is insoluble in butadiene and its homologues. It is dark in color, and may be converted to a white compound by water or alcohol, and may be used for polymerizing further quantities of the dienes.

Sodium butadiene caoutchouc by the Matthews process may be improved by the use of sulfur dioxide.[19] Liquid sulfur dioxide is added to a cooled benzene solution of the soluble part of the caoutchouc and the mixture warmed in a sealed vessel at 40 deg. C. After some time the vessel is opened, when the solution will be found to be very viscous and in some cases set to a jelly. A portion of the caoutchouc may even be precipitated, according to the nature of the original rubber, the concentration of the solution, and the quantity of sulfur dioxide added. On removal of the sulfur dioxide the product will be found to be elastic and to resemble natural caoutchouc. In this condition it may be compounded.

In comparing various synthetic caoutchoucs, Harries[20] found the bromides and nitrosites unsuitable, and concluded that the best method was to measure the velocity of decomposition of the diozonides and dioxozonides with steam, and quantitatively determine the reaction products. The diozonide $2O_3$ is the first product of ozonidation, the dioxozonide $2O_4$ is obtained by prolonged action of concentrated, unwashed ozone.

A comparison such as the foregoing is certainly very valuable to the organic investigator, but of little use to the rubber chemist. To him the most important points concerning a new variety of rubber are as follows:

(1) Can it be vulcanized readily?

(2) What are the physical properties, ie., its tensile strength, elasticity, set, etc.?

(3) Can it be compounded?

(4) What are the aging properties?

I have purposely omitted a prime essential—cost. It is of greatest importance to know what value this new rubber will give. A synthetic rubber to be a commercial possibility must give dollar for dollar an equal or greater value than the natural rubber, which could be sold if necessary at 25 cents per pound.

The method of polymerization has quite an effect on the properties of the product. Hinrichsen[21] has prepared caoutchouc from butadiene, isoprene and dimethylbutadiene. The chart below shows the variation in properties.

A—indicates auto-polymerization by heating.

B—the same, but in presence of ozonides or peroxides as catalysts.

C—polymerization by means of sodium in the presence of carbon dioxide.

D—polymerization by sodium alone.

[15] Ann., 383, 157-227.
[16] Brit. Pat., 24,790, 1910.
[17] Ann., 1911. 383, 157.
[18] Brit. Pat., 26,550, 1912.
[19] Brit. Pat., 2,070, 1914, Matthews & Strange.
[20] Ann., 395, 211-64.
[21] Zeit. des Ver. Deut. Ing., 1915.

A—Indicates auto-polymerization by heating.
B—The same, but in presence of ozonides or peroxides as catalysts.
C—Polymerization by means of sodium in the presence of carbon dioxide.
D—Polymerization by sodium alone.

Manner of Polymerizing	Butadiene	Isoprene	Dimethyl-Butadiene
A	Elastic Easily soluble Capable of vulcanization	Elastic Easily soluble Can be vulcanized	Easily soluble Non-elastic Can be vulcanized to hard rubber only
B	Insoluble Very elastic Strongly inflatable Cannot be vulcanized	Soluble only after calendering Elastic Capable of vulcanization	Soluble only after calendering Inflatable Non-elastic Easily oxidized Vulcanized with difficulty
C	Insoluble Moderately elastic Non-inflatable Cannot be vulcanized	Insoluble Elastic Non-inflatable Can be vulcanized	Insoluble Non-inflatable Non-elastic Easily oxidized Vulcanized only with difficulty
D	Elastic Easily soluble Capable of vulcanization	Easily soluble Non-elastic Vulcanized only with difficulty	Soluble and insoluble modifications Inelastic Incapable of vulcanization

The sodium caoutchouc from dimethyl-butadiene is of scientific interest because of its resemblance to gutta percha. Piperylene rubber is probably an isomeride of natural rubber. The nitrosite, bromide and ozonide decomposition velocity differ decidedly from those of normal caoutchouc.

The foregoing gives a rather brief summary of the various methods of polymerization. We now come to the preparation of these hydrocarbons. This subject is so broad that a full review is entirely beyond the scope of this paper. A large number of investigators are at work, both in this country and abroad, and it would be almost an impossibility to bring the matter up to date.

Because of the large number of methods an attempt to generalize has been made. Only the more important of these general methods will be touched.

Preparation of Butadiene and Its Homologues

I—BY THE CRACKING OF CYCLIC AND STRAIGHT CHAIN HYDROCARBONS

Turpentine.—It has long been known that isoprene may be obtained from turpentine. The hydrocarbon used by Tilden in his experiments was obtained from this source. Harries[22] has described his isoprene lamp.

It has been shown[23] that the isoprene from commercial turpentine is due to the pinene fraction, but Schörger and Sayre[24] are of the opinion that the heating first produces dipentene (limonene), which on decomposition yields isoprene. They further propose that a method whereby pinene may be converted to limonene would be of considerable value, since pinene yields only about 8 per cent isoprene while approximately 50 per cent may be obtained from dipentene.

A patent, U. S. 1,185,654, June 6, 1916, to E. Gottschalk, describes the cracking of pinene, which is brought about by passing the vapor through a glass, porcelain or sherardized metal tube, heated to 300 to 350 deg., producing isoprene and other hydrocarbons, which are quickly cooled, and then subjected to steam distillation.

Another patent, by A. Heinemann, U. S. 1,095,395, deals with the cracking of the vapor of turpentine, which is passed through finely divided copper in an iron tube, or through a helical, spiral, or zigzag copper tube, heated to 480 deg. A yield of 25 per cent isoprene is claimed.

In view of the above it seems quite probable that a means may be found for preparing pinene, and from it isoprene as a by-product, from the great pine forests of the West and South.

Petroleum.—It has been proposed to utilize the low-boiling point members of unsaturated petroleums, such as California oil, in the preparation of isoprene, etc. In view of the success Rittmann, Egloff and others have had in cracking petroleum to benzole and toluene, it seems to me that the production of butadiene and its homologues by somewhat the same methods would be possible.

In their cracking processes a certain amount of gas is always produced, which consists in large part of olefines. It has occurred to me that the condensation of this gas might show us a source of isoprene, thereby making it so valuable that there would be no necessity for burning it in the crackers.

In German patent 264,245, 1911, to Ges. Für Teerverwertung, a method is given for the conversion of crude butadiene, found in the lowest boiling fractions from the distillation products of coal and the crude products resulting from the distillation of mineral oils, to a form suitable for polymerization. After the carbon bisulfide is removed, the cyclopentadiene is thermolyzed into a higher boiling polymer, the hydrocarbons of the acetylene series are removed by aid of their sodium compounds, and the butadiene is fractionated to the desired degree of purity.

Bayer & Company[25] have a method for the production of butadiene by breaking down petroleum fractions or residues with the aid of hot-contact substances, which are placed in the liquid petroleum.

Fats.—German patents 267,079, 267,080, 1912, to Gerlach and Koetschau, covers the production of butadiene and other unsaturated compounds by the cracking of oleic acid, its isomers and homologues, or the oil fats and waxes derived from the acids of the oleic series, or which contain such compounds, also wool fat or other materials containing cholesterol.

Condensation

Acetylene.—The possibilities of the condensation of this hydrocarbon with olefines has always proved a very attractive problem to the young chemist. For example, Heinemann[26] proposed the preparation of isoprene by heating a mixture of acetylene, ethylene and methyl chloride.

$$C_2H_2 + C_2H_4 + CH_3Cl \rightleftharpoons CH_2 : C(CH_3) \cdot CH : CH_2 + HCl$$

Unfortunately, this rather beautiful equation is unworkable.

Acetaldehyde and Alcohols.—The researches of Ostromuisslenskii along this line are of considerable interest. He has been able[27] to produce butadiene by the condensation of acetaldehyde and paraldehyde with alcohol in the presence of various catalytic agents, such as red phosphorus, glacial phosphoric acid, sulfanilic acid, barium chloride, and especially alumina. Best results were obtained from the latter substance at 360 to 460 deg. C. The mixed vapors are quickly heated to reaction temperature, and the products quickly removed and cooled. A yield of 16 to 18 per cent of pure butadiene is claimed.

Ostromuisslenskii mentions that there are four intermediate compounds formed: α hydroxyethyl ether, β, δ, dihydroxy butane, δ hydroxy Δ, β butylene, and methyl allene.

Applying this method to the production of piperylene, he condenses isopropyl alcohol with acetaldehyde in the presence of alumina at about 400 deg. C.

$$CH_3CH(OH)CH_3 + CH_3CHO \longrightarrow OH \cdot CH(CH_3) \cdot CH_2CH(CH_3)OH$$
$$\longrightarrow 2H_2O + CH(CH_3) : CH \cdot CH : CH_2$$

No trace of isoprene is to be found, and the method is said to be the cheapest and simplest of any yet put forth. It is interesting to note that Ostromuisslenskii is able to produce his acetaldehyde directly from alcohol,[28] by passing the vapor, mixed with air, through spirals of copper and silver gauze, producing acetaldehyde mixed with paraldehyde.

It will be remembered that when the Czar made Russia dry territory shortly after the great war started in 1914 that his Minister of Finance, when faced with a $500,000,000 deficit because of the shutting off of vodka revenue, offered a number of cash prizes for a commercial process whereby the alcohol from his distilleries might be utilized.

From the Jan. 5, 1916, issue of the *India Rubber Journal* we learned that the Minister of Finance has proposed the expenditure of £30,000 to erect a factory

[22] J. Chem. Soc., 1911, i, 798.
[23] Herty & Graham, J. Ind. Eng. Chem., 6, 803-4.
[24] J. Ind. Eng. Chem., 7, 924-6.
[25] German Pat., 283,162 and 251,217.
[26] Brit. Pat., 21,772, 1907.
[27] J. Russ. Phys. Chem. Soc., 47, 1509—28, 1494-1506, 1507-09, 1915. Chem. Abst., 10, 3178-9 (1916).
[28] Agr. Gaz. Petrograd, 25, 701 6; 26, 727-8; Chem. Abst., 10, 3000, 1916.

for the preparation of synthetic rubber from alcohol by a process invented by Ostromuisslenskii.

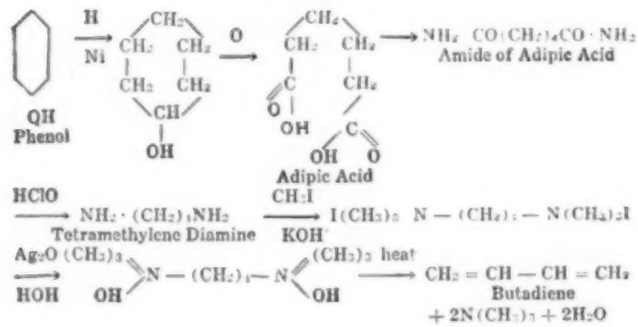
The process here spoken of is in all probability the one described above. In view of the ever-increasing "dry" sentiment in this country, it seems that this matter would bear investigation and research on the part of the great American distilleries, which may yet have to turn to the manufacture of industrial alcohol.

This Russian chemist has lately published some rather remarkable work on the vulcanization of rubber, the preparation of synthetic caoutchouc, and the nature of the rubber hydrocarbon. With it all, he has come in for some very severe and, to my mind, undeserved criticism. The fact that he has been able to convince the Minister of Finance of an almost bankrupt nation, a nation at war, that his processes are worth risking £30,000 on a tryout, is certainly a point in his favor. It may be that like other investigators he finds it necessary to refrain from publishing some of the important details of his work, so as to protect himself from infringement.

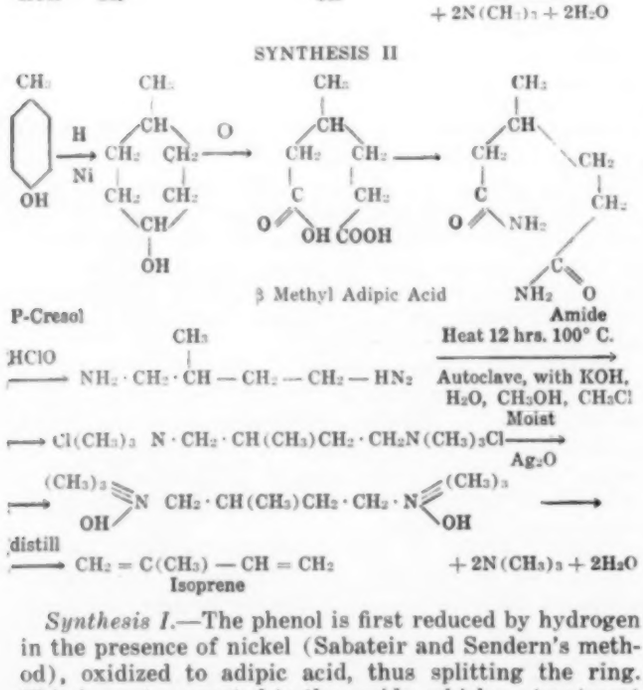
Opening the Benzene Ring

From Coal Tar.—A process for the large scale production of isoprene and butadiene has been worked out by Hoffmann and patented by Bayer & Company.[29] The starting point is either phenol or para-cresol, depending upon whether butadiene or isoprene is desired. Both phenol and p-cresol may be obtained from coal tar, as well as from benzole, by known methods.

SYNTHESIS I



SYNTHESIS II



Synthesis I.—The phenol is first reduced by hydrogen in the presence of nickel (Sabateir and Sendern's method), oxidized to adipic acid, thus splitting the ring. This is next converted to the amide, which on treatment with hypochlorus acid is converted to tetramethylenediamene, which in its turn is treated with caustic potash and methyl iodide. The product is treated with moist silver oxide, converting it to a base, which on heating yields butadiene, water, and trimethyl amine.

Synthesis II.—For isoprene, para-cresol is used, and the only difference in the process is that the β methyltetramethylenediamine is heated with methyl chloride, methyl alcohol, water, and caustic potash instead of methyl iodide and potash as above.

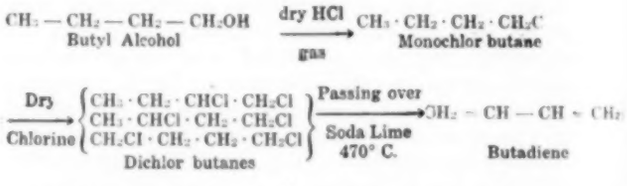
These are truly remarkable syntheses, and that they are workable on a large scale is certainly a credit to the German chemists. It is understood that these two processes supply most of the synthetic rubber now manufactured in Germany.

Fermentation

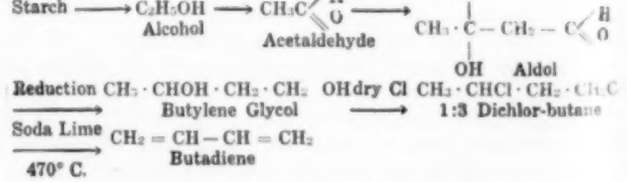
From Starch.—As is well known, small amounts of fusel oil are produced in ordinary alcoholic fermentation. It is a by-product, and while extremely valuable, it must be separated from liquors containing it because of physiological effects. It occurred to Fernbach that if the bacteria causing the formation of the higher alcohol could be isolated and allowed to act alone on starch that a cheap source of butyl alcohol would be provided.

With this in view, Fernbach and Strange[30] were able to devise processes for the production of acetone and butyl alcohol. The fermentation of starch by the *butylic bacillus of* Fitz is accelerated by the products resulting from the action of *Tyrothrix tenuis bacillus* on the nitrogenous matter present in yeast. It is claimed that a yield of 42 per cent fusel oil is obtained.

The butyl alcohol is converted by dry hydrochloric acid gas to chloride, which is then treated with chlorine gas under carefully regulated conditions, producing three dichlorides. On passing the dichlorides over soda lime at 470 deg. C. butadiene is obtained.



By the Acetaldehyde route.—This method, devised by Perkin, Jr., consists in converting starch by yeast to alcohol, then by oxidation to acetaldehyde, to aldol by potassium carbonate, which is next reduced to butylene glycol. The glycol is treated with dry chlorine, converting it to 1:3 dichlorbutane, which on passing over soda lime yields butadiene.



In view of the late work on dehydration of secondary alcohols by Kyriakides, Spence, Ostromuisslenskii, and others, this process looks very old-fashioned, and needlessly long. It has probably been abandoned.

Both Perkins' process and that of Fernbach and Strange, were worked by the Synthetic Products Company, a London corporation. Since this concern has lately come to grief, it might be of interest to trace some of its difficulties.

[29]Eng. Pat., 24,298, 1909.

[30]English Patent, 15,203, 15,204, 16,925 (1911).

(1) It was proposed to secure their starch from potatoes. The *Gummi Zeitung* has estimated that for the production of 10,000 tons of rubber it would be necessary to plant 1,000,000 acres. Discounting this 50 per cent for prejudice, still necessitates a rather large tract of land. Evidently they did not give enough consideration to the source of their raw material.

(2) There was difficulty in sterilizing their mash before inoculating it with the special bacteria. This difficulty seems to have been remedied.

(3) The next trouble was in converting the butyl alcohol to rubber. Since the fermentation end could not produce acetone without also producing normal butyl alcohol, this material piled up, and there seems to have been no ready market for it. Later the British Government took over the Rainham Works where their rubber plant was installed, and they had to stop experiments.

(4) They then attempted to sell their acetone to the British Government, but were told that they were not fit persons to deal with, on the ground that they did not own the patents under which they were working, and that with Sir William Ramsay and Perkin, Jr., interested in the company.

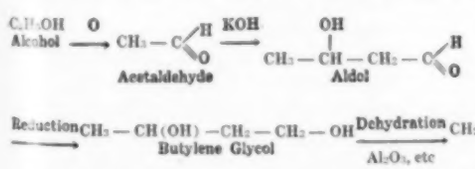
(5) In two years they spent about £40,000. This figure has been held up by the skeptics as a great sum. It only proves that the investigators were short of funds. With a stake like synthetic rubber in view they should have had at least $1,000,000 for experiments.

I have gone into this subject rather deeply, only to impress upon your minds that a great advance in rubber chemistry, as in other lines of research, is only obtained after a great expenditure of time, labor, and money. The fermentation part of their process seems to be good, and there have been rumors of a sale of the patent rights to a large rubber company in this country.

Dehydration

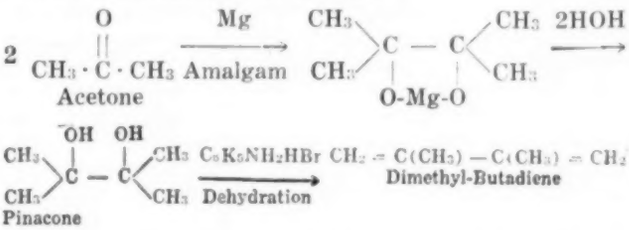
Quite a lot of work has been done on the dehydration of secondary and tertiary alcohols and ethers. A very creditable portion of this investigation has been done by Kyriakides, who has published several interesting papers on the subject.[31]

Dehydration offers many interesting lines of investigation to the research chemist. For example, ethyl alcohol may be readily oxidized to acetaldehyde, which in its turn can be converted to aldol. This is best performed by the method of Grignard and Abelmann,[32] which consists in treating an ethereal solution of an aldehyde or a mixture of aldehydes with a solution of potassium hydroxide, and stirring in the cold. Kyriakides found that acetone could be substituted for ether, and sodium sulfite for caustic. Electrolytic reduction in dilute sulfuric acid solution converts aldol to butylene glycol, which on dehydration yields butadiene.

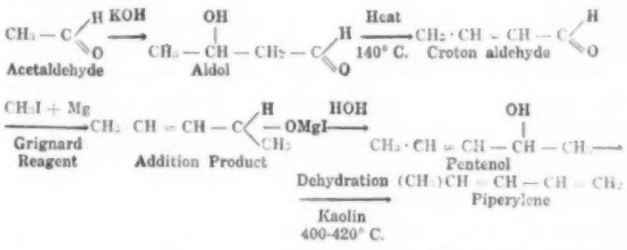


The dehydration was performed by Kyriakides with the aid of aluminium phosphate, kaloin, and aluminium silicate at various temperatures, depending upon the material. Under certain conditions aniline hydrobromide may also be used. Spence[33] mentions the use of potassium bisulfate. British Patent 2,777, 1913, covers the dehydration of crotonyl alcohol by heating with bisulfate of potassium or toluidine, anhydrous oxalic acid, phosphoric acid, aluminium chloride, oxide, etc.

Acetone, on treatment with magnesium amalgam, yields an addition product which on treatment with water gives pinacone, (method of Holleman). If pinacone be heated with a small quantity (20 grams to 1500 grams the hydrocarbon) of aniline hydrobromide, a yield of 70 per cent of the theoretical amount of dimethyl butadiene may be secured.[34]



Piperylene may be prepared by means of the Barbier-Grignard reaction from crotonaldehyde, and methyl iodide, dehydrating the penten 2 *ol* 4 by distilling it over kaolin at 400-420 deg. C. at 60 to 75 mm. pressure. Crotonaldehyde may be prepared from aldol by the elimination of water, which takes place on heating at 140 deg. C.



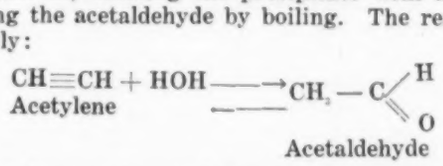
As an example of oxide dehydration described by Kyriakides[35], we will take the dehydration of methyl butylene oxide.

This substance, $CH_2 - CH_2 - C(CH_3) - CH_2$ may be prepared by Grignarding chlor-acetone with ethyl bromide, and treating the resulting product with caustic potash.

A mixture of isoprene and methyl butanal may be obtained by the distillation of methyl butylene oxide through a glass tube, containing freshly prepared and ignited kaolin, heated to 440-460 deg. C. at about 60 mm. pressure. The methyl butanal may be dehydrated to isoprene. Kyriakides considers that by properly regulating the conditions the dehydration of methyl-butylene oxides 1, 2, can be made very nearly quantitative.

You will notice that a number of the last named methods start with acetaldehyde, which is too expensive for their commercial utilization. A cheap method of preparing the aldehyde would make them possible.

Acetylene as a source of acetaldehyde has long been under investigation. Dubosc[36] describes a process for its production by passing acetylene into a solution of mercuric chloride, treating the precipitate with acid, and removing the acetaldehyde by boiling. The reaction is primarily:



The acetylene series contains other interesting members, thus methyl acetylene or allylene, $CH \equiv C - CH_3$, on treatment with water yields acetone.

[31] J. Am. Chem. Soc., 1914, 36, 530-657-663-980-987.
[32] Bull. soc. chim. (4), 7, 638 (1910).
[33] Brit. Pat., 21,173, 1912.
[34] J. Am. Chem. Soc., 36, 993 (1914).
[35] J. Am. Chem. Soc., 36, 663.
[36] Le. Caout. et la Gutta Percha, 1912, 6713.

$$CH_3 - C \equiv CH + HOH \rightleftharpoons CH_3 - CO - CH_3$$

Methyl Acetylene Acetone

To the best of my knowledge these reactions are mainly of interest from a theoretical standpoint, and have no practical application. It seems, however, that there is a slight tendency for them to take place. All reactions are susceptible to the influence of catalysers. If acetylene and water tend to produce acetaldehyde, the means must exist whereby the reaction may be forced. A thorough search for the proper catalyst would doubtless bring this about.

From a standpoint of industrial preparedness, a cheap synthetic rubber would be our salvation. The average man little considers the absolute need of rubber, both for peace and for war. Should the seas ever be closed to us, under present conditions, the suffering would be colossal.

As I have mentioned in a previous paper, we have only three ways to absolutely protect ourselves:

(1) Cultivate and harvest guayule by scientific methods.

(2) Develop something from milkweed, or related plants.

(3) Work up a good synthetic rubber.

There are now in this country several investigators of real worth at work on synthetic caoutchouc. They deserve every consideration and every possible help.

Should this problem ever be solved, I venture to predict that the starting point will be either a derivative of petroleum or a product of acetylene.

Should it never be solved, the possibility of its solution will serve as a spur to drive the planters to greater economy, and better methods of production. Consequently the public will benefit either way, since the price of rubber must constantly decline.

This country of ours must be made economically independent. In this and in two previous papers (Guayule and Industrial Preparedness, The Rubber Situation), I have tried to convey an idea as to just how badly we might be off for rubber. I have also tried to indicate certain means by which the present condition may be alleviated. If I have succeeded in arousing your interest, then I am content.

Alcohol Plants Offered to Government.—Along with many chemical and industrial plants which have been offered to the Government, the Distillers Securities Company has placed its alcohol plants at the Government's disposal. The company controls at least 100 separate establishments for distilling and handling ethyl alcohol.

Institute of Metals Meeting.—The annual meeting of the Institute of Metals was held on March 21 and 22 in London. The president, Sir George Beilby, presided. A special feature of the meeting was a general discussion on metal melting. Abstracts of several of the papers presented on this subject will be found under synopsis of recent literature in this issue. A report was presented on the Corrosion Research Committee, which had been reconstituted during the past year. The laboratory of the committee was transferred to the Royal School of Mines. Work has been commenced on a scheme including a detailed study of a number of factors which have been suggested as determining the initiation of corrosion, and an attempt to estimate their relative importance in the case of a pure metal. A start has been made on the study of certain physical factors, and on the influence of small quantities of "impurities," such as oxide. It is believed that the knowledge so obtained will help materially in the interpretation of results already obtained in the investigation of brass and other alloys.

Effusion Method of Determining Gas Density*

By Junius David Edwards

The effusion method of determining gas density has been in common use for over half a century, in practically the same form as originally developed by Bunsen[1] and Schilling[2]. This method is based upon the fact that the times required for the escape of equal volumes of two gases under the same pressure through the same small orifice are approximately proportional to the square roots of the densities of the gases. Frequent lack of agreement between the different users of this method has given rise to many controversies regarding the accuracy of the method. Because of this unsatisfactory state of affairs the Bureau of Standards, at the request of certain gas companies, undertook an investigation in order to discover the sources of error in the method and to develop the apparatus and technique necessary to secure the best results.

Preliminary Tests

As a part of the investigation, a preliminary series of tests was made at the Bureau with the co-operation of Messrs. S. S. Wyer, T. H. Kerr, P. M. Biddison, H. T. Ashton, and T. R. Weymouth. These tests were designed to determine the accuracy of the method as used under field conditions by experienced observers.

The majority of the tests were made with two pieces of apparatus, one of which is illustrated in Fig. 1. The second apparatus was practically the same except that it had a three-way cock with a side outlet instead of the simple two-way cock shown in Fig. 1. The pressure at the start of each test was approximately 8 in. of water; that at the finish is given in the table.

The specific gravity of the gases used was carefully determined by the method of direct weighing described in a succeeding section. The results are thus referred to a standard method of the required accuracy. From inspection of the results it is seen that results in error by as much as 13 per cent were obtained with one of the orifices tested.

No consistent improvement in accuracy was obtain-

*Published by permission of the Director, Bureau of Standards. The investigation, of which this paper is a condensed report, will be published in full as a Technologic Paper of this Bureau.

[1]Bunsen, Gasometrische Methoden 1857, p. 128.

[2]Schilling, Handb. d. Steinkohlengasbeleuchtung, 3d edition, p. 100.

TABLE I—PRELIMINARY SERIES OF TESTS WITH EFFUSION APPARATUS

(A) Tests made with natural gas of specific gravity 0.752 (saturated gas with water vapor referred to saturated air at 20 deg. C., 760 mm. pressure.)

Test	Orifice	Effusion Pressure at Finish (Inches of Water)	Apparent Specific Gravity	Error (per cent)
1	13	2.0	.695	− 7.6
2	13	0.5	.696	− 7.5
3	13	2.0	.704	− 6.4
4	13	0.5	.684	− 9.0
5	13	0.5	.671	−10.8
6	13	2.0	.648	−13.8
7	13	0.5	.687	− 8.6
8	4	2.0	.764	+ 1.6
9	4	2.0	.764	+ 1.6
10	4	2.0	.764	+ 1.6
11	4	2.0	.768	+ 2.1
12	4	2.0	.764	+ 1.6
13	4	2.0	.764	+ 1.6
14	4	0.5	.756	+ 0.6
15	1	2.0	.762	+ 1.3
16	1	0.5	.748	− 0.6
17	5	2.0	.739	− 1.7
18	11	0.5	.712	− 5.3
19	11	2.0	.721	− 4.1
20	11	2.0	.728	− 3.2
21	12	2.0	.754	+ 0.3

(B) Tests made with natural gas of specific gravity 0.650 (saturated gas referred to saturated air at 20 deg. C., 760 mm. pressure).

22	13	2.0	.627	− 3.5
23	4	2.0	.657	+ 1.1
24	11	2.0	.634	− 2.5
25	12	2.0	.644	− 0.9
26	50	2.0	.629	− 3.2

able by several variations in the method of operation nor was any satisfactory explanation of the results forthcoming from a consideration of the theory of the effusion process as understood at that time. For further progress a better understanding of the theory was therefore necessary, and this phase of the problem was next investigated.

Theory of the Effusion Method

The fact that the speeds of effusion of different gases are approximately inversely proportional to the square roots of their densities was empirically discovered by Graham[2] and others, and its use as a means of determining the specific gravity of a gas was suggested by him. On the basis of the kinetic theory of gases, the speed with which a gas will pass through a small opening (speed of effusion) must be proportional to the average speed of the molecules. Since the molecular speed of a gas is inversely proportional to the square root of its density, the rate of effusion is inversely proportional to the same quantity. The times t required for the effusion of equal volumes of different gases under equal pressures are therefore directly proportional to the square roots of the densities of the gases.

$$\text{Specific gravity} = \frac{d\ (\text{gas})}{d\ (\text{air})} = \frac{t^2\ (\text{gas})}{t^2\ (\text{air})}$$

This theory assumes that the process is isothermal and that there is no loss of energy through friction in the orifice. At atmospheric pressure it is known that these conditions are not satisfied; the phenomenon is one of stream line flow and is affected by a number of factors of which the kinetic theory takes no account.

The effusion method is not concerned with the absolute rate of effusion of any gas, but only with the ratio of the rate of effusion of the gas and of air. For this reason it may be expected that deviations from the law will result from differences in certain physical properties of the gases, such as the ratio of the specific heats, the viscosity, the thermal conductivity, etc. However, because of the number of factors involved, the complete development of the theory has proven to be very difficult and a satisfactory correlation of all the variables has not yet been accomplished. It is desired at this time to present only the empirical relations between variables as shown directly by the experiments and leave to a later paper the theoretical discussion of these. The development of the theory has been done in collaboration with Dr. Edgar Buckingham of the Bureau.

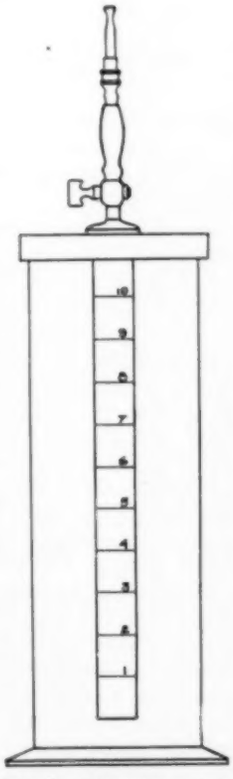


FIG. 1—EFFUSION APPARATUS USED IN PRELIMINARY TESTS

[2]Phil. Mag. (3) 2, p. 175; 1833.

Experimental Apparatus and Methods

Gases Used.—Three samples of natural gas and one each of hydrogen, carbon dioxide, air, and argon (containing 33 per cent argon) were used. The gases were

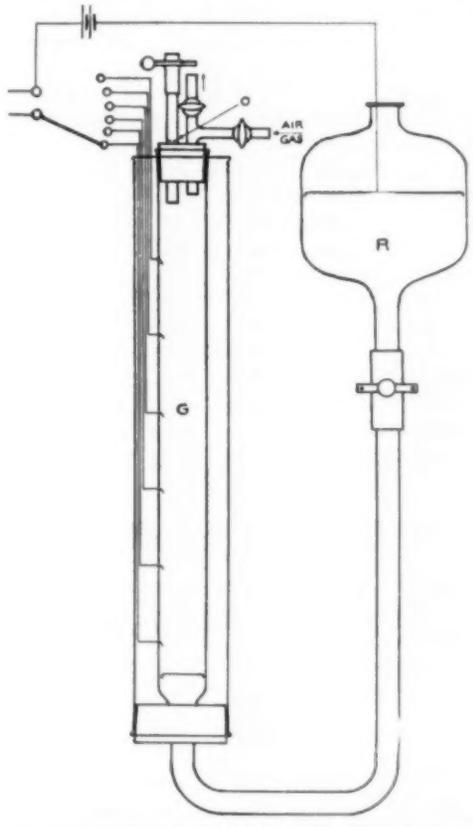


FIG. 2—EFFUSION APPARATUS FOR STUDYING EXPERIMENTAL CONDITIONS

delivered from steel cylinders at the proper working pressure by means of pressure regulators.

Standard of Comparison.—The density of the gas contained in each cylinder was determined by direct weighing of an accurately determined volume of gas, at a definite pressure and temperature in a glass globe. The specific gravity of the gas was calculated from this weight and the weight of an equal volume of air determined in the same way.

Effusion Apparatus.—The apparatus used in the study of the variables of the effusion process is shown in Fig. 2. This apparatus was used especially for studying the effect of pressure upon the rate of effusion. It consists of a cylindrical chamber G, containing the gas, connected by a glass tube to the mercury reservoir R. The rubber stopper closing the gas chamber carried the orifice tube and the tube for introducing the gas and air, as shown. The gas could be introduced at any desired pressure.

An automatic electrical method of timing was used. A series of platinum contacts properly insulated on the outside were sealed into the walls of the gas chamber at approximately equal intervals. When the gas was effusing, the ascending column of mercury, closing the circuit at each terminal, recorded the time of contact on a chronograph operated by the master clock of the Bureau. The time of effusion for different intervals could, by this means, be determined to 0.05 second. Observational error in the timing was thus practically eliminated.

Orifices.—Each orifice was made by piercing a small hole in a metal plate, and sealing it into a glass tube. All the orifice plates used for this investigation were of

platinum-iridium (15 per cent iridium); this alloy makes a very stiff and serviceable plate. The orifice plate, usually 5 to 6 mm. in diameter was pierced by a needle of approximate size, using a soft metal backing. The hole was then cleaned out and enlarged as desired by proper reaming with a needle. Any burr could be removed and the plate ground down to the desired thickness by careful grinding on fine emery paper. When finished, the thickness of the plate was determined by means of micrometer calipers and the diameter of the orifice was determined with the aid of a microscope. The microscope was also used in determining the condition of the orifice during the finishing process. The plate, when completed, was sealed into the end of a glass tube and another glass tube sealed on next to it. The finished orifice then consisted of a platinum-iridium plate sealed into the center of a glass tube.

The tubes were numbered by etching so that either face of the orifice plate could be identified at any time. The letters *A* and *B* are used to distinguish the two sides of the orifice. For example, when "orifice 10*A*" is used it means that orifice number 10 was used in such a position that the gas passed through the orifice from side *A* to side *B*.

Effect of Experimental Conditions Upon the Apparent Specific Gravity

The effect of variation of effusion pressure on the relative rates of effusion of air and hydrogen, argon, methane, and carbon dioxide through the same orifice, (No. 28B) are shown by the curves in Fig. 3. The values of *R*, plotted as ordinates, are the ratios of the apparent specific gravities $\left(S = \frac{t_g^2}{t_a^2}\right)$ to the true specific gravity of the gas. The values of *r* plotted as abscissas are the ratios of the back pressure (atmospheric) to the effusion pressures. For example, if the atmospheric pressure is 760 mm. of mercury and the average effusion pressure is 190 mm. in excess of the pressure of the atmosphere, then $r = \frac{760}{760 + 190} = 0.80$.

The values of *r* nearest 1.0 represent the lowest effusion pressures.

A number of facts are at once evident from an examination of these curves. They illustrate in a striking manner the very different behavior of different gases. Different orifices give curves which have the same characteristic form for a given gas, although the values of *R* vary considerably. The apparent specific gravity is distinctly a function of the pressure. The combination of factors, which produces such a low result in the case of carbon dioxide, produces just the opposite effect in the case of hydrogen. While there may be a pressure at which the effusion method gives the correct specific gravity for a given gas with a given orifice, there is evidently no effusion pressure at which any one orifice will give the correct specific gravity for every gas.

Except for the correction due to the fact that the effusion is practically adiabatic, the major part of the deviations noted can be explained by differences in the viscosities of the gas and the air. If it were possible to calculate the correction in any given case, the fact that it would require a determination of the ratio of the specific heats, the viscosity, and possibly other physical constants of the gas, would prevent any commercial use of such a method.

The Effusion Pressure.—The effect of variations in the effusion pressure upon the relative rates of effusion of different gases was pointed out in connection with Fig. 3. It may be concluded from these curves and a consideration of a large mass of other data that a very low effusion pressure should, in general, be avoided. However, the converse is not generally true, namely, that the higher the effusion pressure the more nearly correct the apparent specific gravity will be.

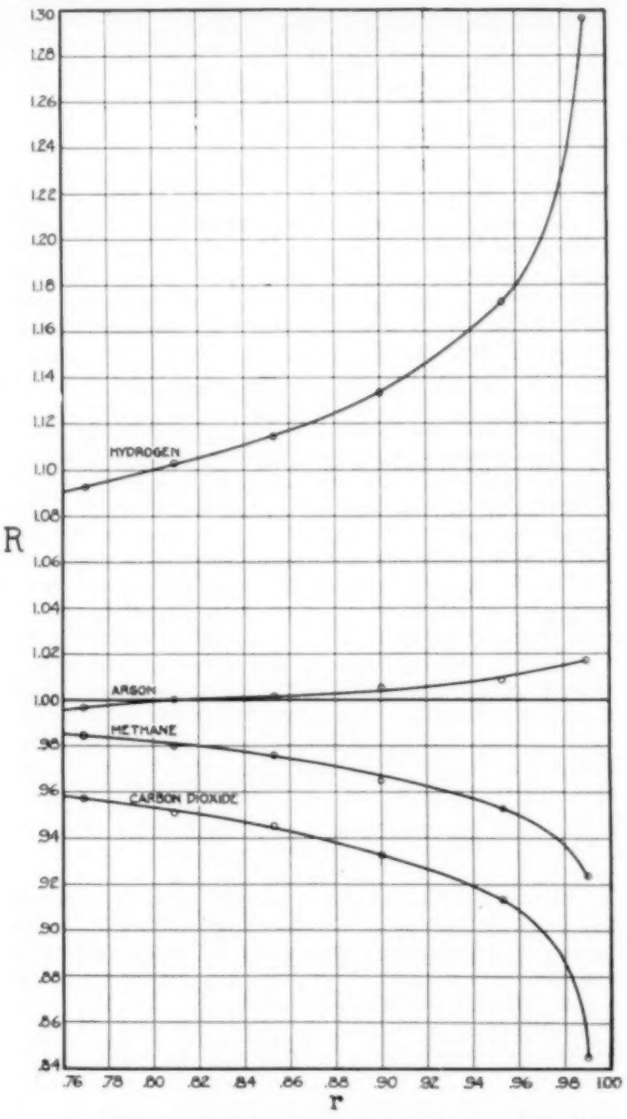


FIG. 3—CURVES SHOWING THE APPARENT SPECIFIC GRAVITY OF DIFFERENT GASES AS DETERMINED WITH ORIFICE NO. 28B AT DIFFERENT EFFUSION PRESSURES

The Confining Medium.—The use of water as a confining liquid is attended with a number of disadvantages. The gas, being in contact with water, must be measured saturated with water vapor at the temperature of the test; and the specific gravity value obtained is then the ratio of the weights of saturated gas and saturated air. The specific gravity of a gas is usually defined as the ratio of the weight of a given volume of gas to the weight of an equal volume of air, dry, free from carbon dioxide, and measured at the same temperature and pressure. This definition may be extended to include the value obtained with the effusion apparatus using water by stating that both gas and air shall be saturated with water vapor. It should be clearly borne in mind, however, that the specific gravity of dry gas referred to dry air may be very different from the specific gravity of saturated gas referred to saturated air. The latter value is, of course, not constant but is different at different temperatures and pressures. For example, if the specific gravity of a gas is 0.500, then the specific gravity of the saturated gas referred to satu-

rated air at 20 deg. C. and 760 mm. pressure will be 0.507.

The expansion of the gas in passing through the orifice results in a considerable lowering of its temperature with the consequent condensation of water vapor. This water frequently adheres to the rim of the orifice, materially changing its diameter and giving erroneous results for the apparent specific gravity since the area of the orifice may vary from one test to the next as water is condensed or evaporated from its walls. When this occurs the effusion time may vary quite erratically. When this difficulty was experienced, passing dry gas through the orifice previous to each test made it possible to secure consistent readings, thus confirming the belief that the condensation of water vapor was the cause of the erratic results.

Mercury is the ideal confining medium from the standpoint of precision since its vapor pressure is negligible and gases are insoluble in it. Its high density may, however, introduce difficulties when it is desired to secure a low effusion pressure. Mercury was used in most of the experiments reported.

The Orifice.—The character of the orifice employed is of prime importance. The shape of the orifice has an important effect upon the relative rates of effusion. The same orifice, used under exactly the same conditions except that the direction of flow through it is changed, may give a different apparent specific gravity, thus showing the effect of changing the form of the orifice (as viewed from the side of the effusing gas) without changing its diameter. In Fig. 4, for example, the curves for orifices 25A and 25B show that reversing the orifice in the apparatus makes a difference of 1 to 2 per cent in the apparent specific gravity.

The experimental results show that, almost without exception with the orifices examined, the position showing the lower air effusion time gives for the natural gas the lower value for the apparent specific gravity. The same factors would have the opposite effect in the case of hydrogen, giving a higher apparent specific gravity. Some idea of the character of an orifice may be obtained by comparing the air effusion times when it is used in both positions. If there is considerable difference, the position giving the longer time is the preferable one to use.

The variation in the apparent specific gravity of methane when determined with six different orifices is shown in Fig. 4. It is to be noted that in form the

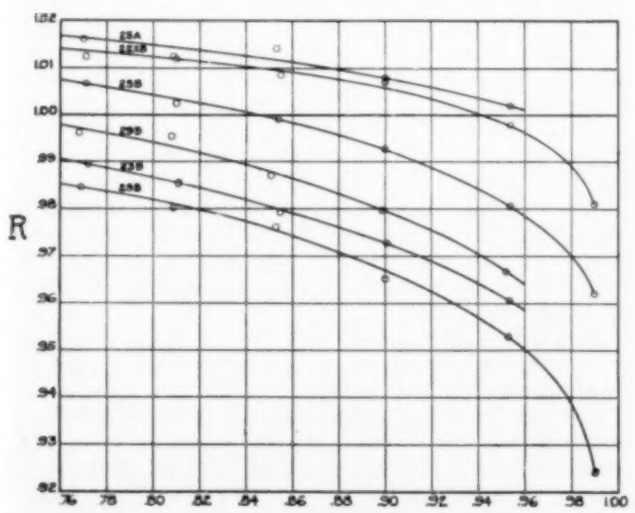


FIG. 4—CURVES SHOWING THE APPARENT SPECIFIC GRAVITY OF "METHANE" (SPECIFIC GRAVITY = 0.583) USING DIFFERENT ORIFICES

curves are quite similar. The characteristics of these orifices were as follows:

Orifice 25.....0.12 mm. diameter.....0.09 mm. thickness of plate
Orifice 22.....0.09 mm. diameter.....0.02 mm. thickness of plate
Orifice 29.....0.05 mm. diameter.....0.05 mm. thickness of plate
Orifice 23.....0.06 mm. diameter.....0.04 mm. thickness of plate
Orifice 28.....0.07 mm. diameter.....0.10 mm. thickness of plate

Similar series of curves have been obtained for the other gases used. The results are in each case a set of nearly parallel curves with the same relative arrangement with respect to the orifices. With curves shaped like those for carbon dioxide or methane in Fig. 3 the larger orifice gives the higher result; but with curves like those for hydrogen and argon the larger orifice gives the lower values.

These with other results show that, in general, an increase in the thickness of the plate or decrease in the diameter of the orifice results in a lower apparent specific gravity for the methane. In the case of hydrogen the converse is true, the same changes producing an increase in the apparent specific gravity.

A more definite idea of the effect of size of orifice can be obtained from a consideration of the data in Table 3 where results for methane with fourteen different orifices are recorded.

TABLE III—EFFECT OF SIZE OF ORIFICE

(A) Tests made with mean pressure ratio (r) of 0.92 using methane of specific gravity 0.583.

No. of Orifice	Diameter of Orifice (Mm.)	Thickness of Orifice Plate (Mm.)	Time of Effusion for Air (Seconds)	Apparent Specific Gravity	Error (per Cent)
22XA	.09	.02	587	.580	−0.5
22XB	.09	.02	608	.589	+1.0
21 A	.18	.02	107	.588	+0.9
21 B	.18	.02	107	.590	+1.2
19 A	.25	.02	57	.588	+0.9
19 B	.25	.02	57	.589	+1.0
14 A	.14	.04	160	.575	−1.4
14 B	.14	.04	170	.588	+0.9
16 A	.20	.04	75	.577	−0.9
16 B	.20	.04	84	.585	+0.3
18 A	.19	.06	98	.576	−1.1
18 B	.19	.06	103	.586	+0.5
7 A	.14	.07	145	.582	−0.2
6 A	.19	.07	86	.585	+0.3
8 A	.22	.07	68	.583	0.0

(B) Tests made with mean pressure ratio (r) of 0.99.

22XA	.09	.02	1034	.572	−1.9
22XB	.09	.02	1045	.572	−1.9
21 A	.18	.02	260	.583	0.0
21 B	.18	.02	261	.583	0.0
19 A	.25	.02	134	.586	+0.5
19 B	.25	.02	133	.589	+1.0
30 A	.37	.03	66	.599	+2.7
30 B	.37	.03	65	.598	+2.6
26 A	.15	.04	356	.572	−1.9
26 B	.15	.04	346	.566	−2.9
18 A	.19	.06	249	.571	−2.1
18 B	.19	.06	254	.574	−1.5
27 A	.25	.05	120	.585	+0.5
27 B	.25	.05	120	.584	+0.2
28 B	.07	.10	1772	.539	−7.5
25 A	.12	.09	544	.569	−2.4
25 B	.12	.09	549	.560	−3.9
24 A	.18	.09	255	.579	−0.7
24 B	.18	.09	244	.571	−2.1

The value obtained with orifice No. 30 may be somewhat high, since the high viscosity of the concentrated sulphuric acid used as the confining medium may have retarded the rapid flow of the methane through this large orifice.

Recommendations

a. Types of Apparatus.—The two general groups of apparatus in use may be called the displacement type

and the expansion type respectively. In the first class may be placed those instruments in which one observes the time of effusion of a definite volume of gas actually displaced by the confining liquid. In the expansion-type class may be placed those instruments in which one observes the time required for the effusion of the gas which escapes during the expansion from high to low pressure, the volume remaining practically constant.

The apparatus shown in Fig. 2, is typical of the first class, the space occupied by the effusing gas being filled by the rising column of the confining medium. In Fig. 5 is shown an apparatus of the second type where the driving pressure is obtained almost wholly from the expansion of the effusing gas. In this apparatus the time observed is that required for the pressure in the gas chamber *G* to fall a certain amount as shown by the manometer *M*. The principal advantage of apparatus of the expansion type lies in the small quantity of confining liquid necessary, which is important where mercury is being used.

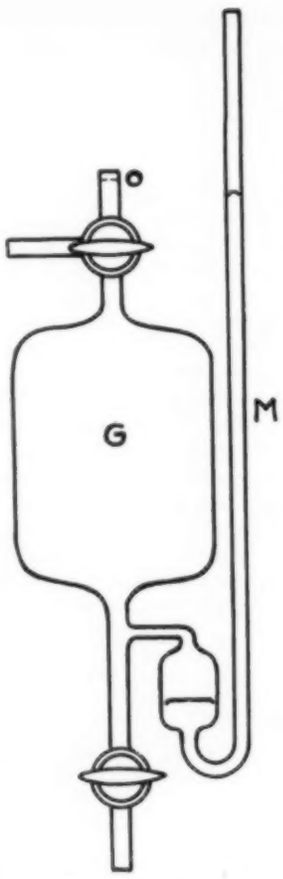


FIG. 5—EXPANSION TYPE OF EFFUSION APPARATUS

It amounts to the same thing whether one determines loss in pressure or change in volume, but the relations between the volume of the gas chamber, the effusion time and the effusion pressures are very different for the two types of apparatus. To secure the same effusion time with apparatus of the expansion type as with the displacement apparatus, it is necessary that either the volume of the apparatus or the effusion pressure be considerably increased. For example, if an apparatus of each form has a gas reservoir bolding 100 c.c., and if the pressure at the start of a test is 1/10 atmosphere above atmospheric and the pressure at the finish is that of the atmosphere, then using the same orifice on each apparatus, the time of effusion will be approximately eleven times as long with the apparatus of the displacement type as with the expansion type. To give the same time of effusion would require a total volume in the expansion apparatus of about eleven times that in the displacement type of apparatus. An interval long enough for accurate timing must be obtained and since increasing the time of effusion by decreasing the size of the orifice is only permissible within certain limits, it may readily be seen that an apparatus of the expansion type with an orifice of the proper size might have to be very large and cumbersome in form; this type of apparatus is not recommended.

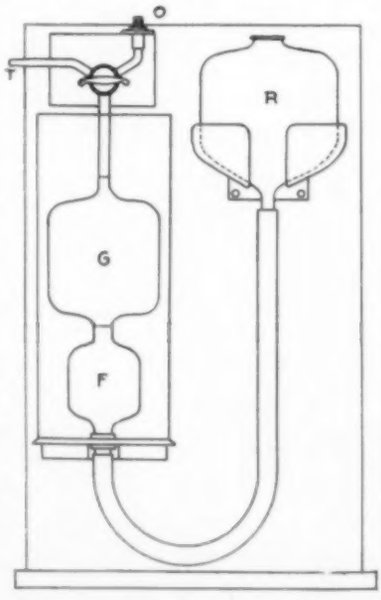


FIG. 6—FORM OF EFFUSION APPARATUS RECOMMENDED FOR USE WITH MERCURY OR WATER

Two forms of apparatus are suggested in the following paragraphs, the first suitable for use with either mercury or water as a confining medium and the second, a somewhat simplified form, suitable for use with water only. There is nothing essentially new in this apparatus; it is a combination of the most desirable features which have been suggested.

b. Forms of Apparatus of Displacement Type.—The form of apparatus shown in Fig. 6, while especially adapted for use with mercury, is equally suitable for use with water if a few minor changes are made so that the effusion pressure is adjusted to a suitable value. The gas chamber *G* should be made spherical or cylindrical in form, as shown, and should have a capacity of about 150 to 200 c. The smaller cylinder *F* is provided so that when the sample is drawn in at atmospheric pressure, there will be sufficient gas capacity to permit the compression of the gas caused by raising the reservoir *R* to its position and yet leave the mercury a suitable distance below the lower graduation. If water only is to be used in the apparatus, this extra capacity can be reduced accordingly. The gas chamber is connected to the reservoir *R* by means of a rubber tube and to the orifice tube *O* by the glass tube and stop cock as shown. The gas chamber is water-jacketed to maintain a uniform temperature.

Reference marks are placed on the tubes just above and below the gas chamber and the time of effusion is determined by observing the interval required for the meniscus to pass between these two marks. The diameter of the tubes at the top and bottom can be so proportioned that the speed of the meniscus is approximately the same both at the start and finish of a run.

Attached to the upper tube is a three-way stop cock by means of which the gas chamber may be connected either to the side tube *T* for filling or to the orifice which is attached at *O*. This stop cock also may be set so that gas can be passed through the orifice from the inlet *T* while the gas chamber is closed off. This makes it possible to sweep out the orifice tube and connections, and eliminates the uncertainty connected with the use of the apparatus shown in Fig. 1, where the space between the stop cock and the orifice is left filled with a mixture of gas and air which one must assume is swept out by the time observations are commenced. When using water with this apparatus, any moisture condensed in the orifice can be removed by passing dry gas or air from this side tube through the orifice; this will be found to be the most convenient and satisfactory way of drying the orifice.

The orifice tube screws onto the small metal support at *O* into the base of which is cemented the glass tube leading from the stop cock.

The reservoir *R* is supported at a fixed height by a holder and is connected to the gas chamber by a large heavy-walled rubber tube, securely fastened in place. By raising or lowering the bulb, gas or air can be forced out or drawn into the gas chamber; but it is essential that the support be so shaped that the reservoir will be always at exactly the same height relative to the gas chamber so that the effusion pressure is maintained

constant. Another support for the reservoir at a lower level is convenient when filling the apparatus with gas.

The apparatus should operate with an effusion pressure of 15 to 20 cm. of mercury at the start of a test and 1 or 2 cm. at the finish; this gives a mean pressure ratio r of about 0.90. If water is being used the pressure should not be reduced below 5 cm. of water at the finish of a test. The length of the tube between the upper mark and the stop cock should be adequate to permit this, if it is intended to use water.

In Fig. 7 is shown a simplified form of apparatus for use with water, which may have certain advantages in some cases.

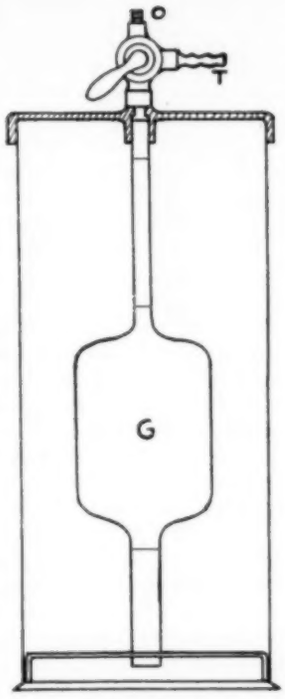


FIG. 7—SIMPLIFIED FORM OF APPARATUS FOR USE WITH WATER ONLY

c. Orifice.—A desirable form of orifice is shown in Fig. 8. The orifice plate, of the form described below, is sealed into the center of a short glass tube, 3 to 6 mm. internal diameter. This tube is mounted with cement in a metal casing, threaded at the end so that it can be attached to the apparatus. The orifice is thus protected from breakage and it can be readily removed for examination or cleaning.

As a guide to the selection of the proper size of orifice, the following general recommendations are made. It should be clearly recognized from the previous discussion of this subject that no definite limits of size can be set but it is believed that the following specifications will aid materially in the construction of a satisfactory orifice.

For apparatus designed to operate with a mean effusion pressure ratio of 0.90 (Fig. 6 used with mercury) an orifice plate 0.05 mm. or less in thickness and having a smooth cylindrical orifice between 0.15 mm. and 0.30 mm. in diameter should prove best adapted for this purpose.

For apparatus designed to operate with a mean effusion pressure ratio of 0.99 (almost any apparatus using water) an orifice plate less than 0.04 mm. in thickness and having an orifice between 0.18 mm. and 0.30 mm. in diameter should be chosen.

c. Standardization.—In control work or where only comparative values are desired on gases of the same general nature, considerable reliance may be placed in the effusion method. Whenever possible it is recommended that a preliminary standardization of the orifice be made. To be significant, it is essential that any standardization be made using a gas of the same character as that to be tested and whose specific gravity has been determined with the necessary accuracy by an independent method. The specific gravity balance for gases described in technologic paper No. 89 of the Bureau furnishes a suitable means of determining the specific gravity for this purpose.

FIG. 8—FORM OF ORIFICE RECOMMENDED

The results shown in Table 1 were thus used to obtain correction factors for the orifices tested with the idea of increasing the precision obtained with them until the method had been more thoroughly investigated. This was practicable since these orifices were being used only with natural gases of the same general character as that employed for the preliminary test. An empirical factor was decided upon which should represent the average amount to be added to the apparent specific gravity to give the correct value; the correction factors recommended for use were for orifices No. 4, —0.010; No. 12, +0.005; and No. 11, +0.020. Table 4 shows the results of a number of these tests.

TABLE IV—FIELD TESTS SHOWING USE OF CORRECTION FACTOR

Gas	Apparent Specific Gravity			Corrected Specific Gravity		
	Orifice 4	Orifice 12	Orifice 11	Orifice 4	Orifice 12	Orifice 11
A	.661	.....	.633	.651	.....	.653
B	.668	.....	.635	.658	.....	.655
C	.681	.....	.647	.671	.....	.667
D	.691	.....	.661	.681	.....	.681
E	.687	.674	.648	.677	.679	.668
F	.683	.682	.644	.673	.687	.664
G	.....	.660	.652	.....	.665	.672
H	.....	.679	.666	.....	.684	.686
I	.....	.648	.643	.....	.653	.663
J	.....	.660	.635	.....	.665	.655

Gas "J" was the same as gas "I" except that the test labeled "I" was made at the measuring station and test "J" was made on a sample taken to the laboratory

e. Operating Directions.—In the preceding sections of this paper, most of the details of operation of the apparatus have been discussed; only a short summary of the operating directions together with certain precautions to be observed will be given here.

The apparatus should be set up and filled with the confining liquid to the proper level; a mark may be placed upon the upper tube at the proper height to aid in reproducing this level.

In filling the apparatus with gas or air, care should be taken to insure an uncontaminated sample by rinsing as many times as may be necessary to obtain constant effusion times in successive tests. The orifice tube and connections must also be filled with the gas sample.

When using a movable reservoir as shown in Fig. 6, care should be taken to replace the reservoir at exactly the same height so that the effusion pressure will not be changed from one determination to the next.

The apparatus should be tested to make sure that there are no leaks in the gas chamber.

Any moisture condensed on the edges of the orifice should be removed by passing dry gas through the orifice. The constancy of the air effusion interval is an indication of whether or not an appreciable error is being introduced from this source.

For a specific gravity determination, several consecutive runs should be made on both gas and air. In general, one should secure three or four intervals which agree within 0.5 per cent, or if the interval be more than two minutes, within one-half second, before the average can be considered as satisfactory. It should be noted that an error of 0.5 per cent in timing makes a difference of about 1.0 per cent in the apparent specific gravity. The accuracy of the stop watch should be checked by comparison with some standard when possible.

In timing, care should be taken to have the eye on a level with the graduation at the time of starting or stopping the stop watch.

Summary

The effusion method of determining gas density, which is based upon the fact that the times required for the escape of equal volumes of two gases under the same pressure through the same small orifice are approximately proportional to the square roots of the densities

of the gases, was investigated in order to determine the accuracy of the method and its sources of error. In co-operation with a number of men employing this method in the natural gas industry, a series of experiments was made using their apparatus under field conditions. It was found that results in error by more than 10 per cent were not unusual.

The theory of the effusion process was investigated in order to determine the influence of the numerous variables affecting the apparent specific gravity. The relative rates of effusion of air as compared with hydrogen, argon, methane, and carbon dioxide at different pressures and with different orifices were determined. A more detailed treatment of the theory in the light of these results will be given in another paper.

The results obtained from this study together with the observations made on the effect of the effusion pressure, the confining medium, and the shape and size of the orifice were used in determining the most favorable conditions of operation for this method. Recommendations are made as to the most suitable type and form of apparatus for use and specifications given to guide in the construction of the orifice.

Although no results of high accuracy can be expected from apparatus of the effusion type, yet it should serve well for approximate results or for work where relative values only are needed, as in control work.

It has been shown that the apparent specific gravity as determined by this method can be varied within rather wide limits by changing the conditions. However, by the observance of certain precautions in the construction and use of the apparatus, it is possible to secure results accurate to about 2 per cent. The greatest precision is obtained where the physical properties of the gas tested show the least difference from those of air. Some further increase in accuracy and particularly in reliability can be gained by standardizing the apparatus as recommended.

Where a more accurate method is desired, the specific gravity balance for gases described in Technologic Paper No. 89 of this Bureau may be used.

The author wishes to express his indebtedness to Mr. R. S. McBride for his advice and assistance during the course of this work.

Bureau of Standards,
Washington, D. C.

Recent Advancement in Leather Manufacture *

By Allen Rogers

In these days when science is being applied so universally to our manufacturing enterprises, we often wonder what the expert of a generation ago would say if confronted with any of the present-day problems. Even those of us who are in close touch with some special branch of industry often awaken to the realization that while we have been taking a few days' rest, congratulating ourselves upon the knowledge we thought we possessed, such a change has come over our pet that we hardly recognize it. This may be a bit overdrawn, but in the leather trade at least there have been wonderful achievements in recent years and the old-style "rule of thumb" methods have been relegated to the past.

The manufacture of leather, although it dates back to the early days in the Garden of Eden, came down to us practically unchanged for hundreds of years, and it has been only within the past generation that rapid strides in the direction of progress have been made. The old methods, which were carefully guarded as great secrets and shrouded in mystery, have become public property, and, through the efforts of the chemist, have, in many cases, been discarded as crude, wasteful, inefficient, unsanitary, and highly unscientific.

It is hardly within the scope of this paper to go into the details involved in making all the numberless kinds of leather; it is more essential to point out in a general way where some of the old methods have been improved by modern scientific investigation.

The source of leather is to be found in the skins and hides of animals. Since it is here that leather starts, let us note in passing what science has done to improve the hide. Very few people realize that a hide may be ruined while it is still on the back of the animal, but such is the case. Those of us who were fortunate enough to have been raised on the farm or in country villages will remember seeing the lumps which appeared on the backs of cows at certain times of the year. We will recollect that these lumps grew very slowly and then suddenly disappeared. After the swelling went down, a hole was left to show the havoc wrought by the warble fly or grub. The swollen place was formerly supposed to have been caused by the sting of a fly which by some mysterious method laid her eggs under the hide at this particular point. It has recently been shown, however, by the Department of Animal Industry that such is not the case; that, on the contrary, the fly lays her eggs in the fetlock of the animal and that these eggs are taken into the stomach through the mouth. From thence they pass into the loin, where they mature and work themselves out through the hide. If given proper attention by the farmer, this ravage can be easily overcome, and some states have already taken steps to make this a law.

Another destructive agent on hides is the *tick*. This damage occurs in the flanks, and is often so bad that the entire flank is eaten away. This condition is being obviated by driving the cattle through tanks containing a dilute solution of sulphurous acid.

Scratches and brand marks, which have occasioned great distress to the tanner, are slowly being eliminated.

The hides on removal from the slaughtered animals are usually covered with salt and placed in piles to cure. As a result of this curing it is quite common to find hides which have dark spots on them known as salt stains. These spots cannot be removed and show up later on as black patches. The stain, in most cases, is due to the presence of iron in a ferric condition, indicating that partial iron tannage has taken place.

Within the past five years steps have been taken to eliminate the stain, and much has been accomplished by using a small amount of sodium bisulphite in connection with the salt. Hides so treated are always free from stain.

The common practice for removing the hair is to treat the stock with milk of lime to which sodium sulphide is sometimes added. For removing the lime, it is necessary to employ a substance known as "bate." Formerly the material was hen manure or dog manure, but of late years these have been almost entirely superseded by products of a fermentation or enzyme nature, trypsin being the selective enzyme used.

A new process which does away with liming and bating consists also in using a selective enzyme from the start. This process is meeting with considerable success and seems to have a very promising future. The selective enzyme employed is the same form of trypsin as used in bating, but its application is carried out under different conditions. The process, if it becomes a

*A paper read before the New York Section of the Society of Chemical Industry April 13, 1917, in joint session with the New York Sections of the American Chemical Society and the American Electrochemical Society.

commercial success, will entirely eliminate the liming process and so modify the bating that the two operations will be accomplished at one and the same time.

When Augustus Schultz, an American chemist, discovered the two-bath chrome method of tanning leather, he gave to the world a process which revolutionized the whole industry, and had more to do with placing tanning on a scientific basis than any other cause. Not only has this discovery resulted in the bulk of upper leather being of chrome tannage, but it has led to other great achievements. Chrome tannage was at first applied only to goat-skin, but with a better understanding of the use of chromium salts modified processes are being applied to all kinds of stock. One of the latest uses is in making white washable shoes so largely worn at present by the fairer sex. Indestructible sole leather is being made by a chrome combination process, but this does not meet with favor from the shoe manufacturers because its wearing quality is too great.

Washable glove leather is a chrome combination bath of recent introduction and is meeting with increasing popular favor. Formaldehyde is being used as a tanning material, for light leather, when a very white and washable leather is required, but it has its limitations.

Only a few years ago all manufacturers of heavy leather were using hemlock or oak bark as a tanning material. To-day the old-style bark tanning has been almost entirely superseded by the more modern extract plant. That is, barks and woods of various kinds are being treated to obtain their tannin content, and the concentrated extract obtained is sold direct to the tanner. One of the extracts used to-day in greater amounts than any other is quebracho. Ten years ago this material was almost unknown to the American tanner, while at present thousands of tons are being consumed annually. In place of the time-consuming processes which took from one year to eighteen months we are making the bulk of our sole leather in from sixty to ninety days with a resulting leather that is superior in wearing quality, style and ease to the old bark-tanned product.

In the manufacture of paper a by-product has been going to waste for many years in the spent sulphite liquor. This liquor is now being utilized in the manufacture of heavy leather where for certain purposes it is giving very satisfactory results.

Patent leather to-day is not the same weak and brittle product it was a dozen years ago. The reason for this is that the method of treatment is such that it will retain the finish and yet remain strong, while at the same time the finish is as flexible and applied only in thin coats.

With the increased cost of raw material, ways have been devised to utilize the portion which formerly went to waste or brought only a very small return. Thus splits, which five years ago were a drug on the market, are now being converted, by means of dope and other finishes, into a fair grade of shoe upper leather.

Owing to the scarcity of hides and skins and the increased demand for leather, many skins are now being tanned that were formerly considered to be worthless as leather. Thus to-day we find that the hides of whales and skins of fish are being converted into a marketable product.

As a result of the scarcity of hides and skins, various substitutes have been brought forward, so that we have imitation leather for furniture and automobile leather, mat and glaze finished lineoleum products to take the place of upper leather and finally several sole leather substitutes. With all of these, however, the old saying still holds good: There is nothing like leather.

Nitrate Industry in Chile

In our issue of March 1, 1917, pp. 253-259, we published an article on the nitrate industry in Chile by I. Berkwood Hobsbawn. A paper on the same subject by Mr. Hobsbawn and J. L. Grigioni, as joint authors, was presented at a meeting of the London Section of the Society of Chemical Industry and is published in the journal of the society for Jan. 31, 1917. From this paper we take the following information, which describes two of the processes in greater detail, to supplement our previous article:

The year 1912 witnessed the initiation of two processes which are now undergoing commercial development in Chile and which merit detailed description, namely, the Butters process and the Gibbs process.

BUTTERS PROCESS

The following details of the Butters process were taken by the authors from a description given by Mr. J. T. Humberstone at the Mining Congress held in Santiago de Chile in April, 1916, supplemented by reports and descriptions received from private sources.

The Butters process was developed by the Butters Vacuum Filter Co., assisted by Mr. J. T. Humberstone in Oficina Agua Santa, Tarapaca, Chile.

It is based on the use of the Butters vacuum filter as the means by which the nitrate and salt solutions are removed from the insoluble matter. It is proposed to reduce the whole of the raw material to sufficient fineness, by grinding in ball mills with hot weak nitrate solution, that it will be amenable to treatment in the standard Butters filter. After grinding, the pulp is further heated by steam coils, in order to cause solution of the nitrate, air agitation going on the while.

In the Agua Santa works the fines (11 per cent nitrate content) are mixed with liquor (150 grms. nitrate per liter) in the proportion of three of solid to one of liquid. The hot pulp is then filtered in the Butters vacuum filter and a certain proportion of liquor is extracted in this way. This liquor is of varying strength, depending on the amount of weak liquor (and strength thereof) which is used for the extraction and the proportion and richness of the raw material used with it.

The inventors claim that it is possible to prepare a liquor, by this means, which can be sent direct to the crystallizing tanks, but so far this claim has not been substantiated in practice. In fact, the inventors state that it is preferable to work for the preparation of a liquor containing about 450 grms. of nitrate of soda per liter, which would show a density of about 75 deg. Tw. and temperature of about 80 deg. C. Such a liquor

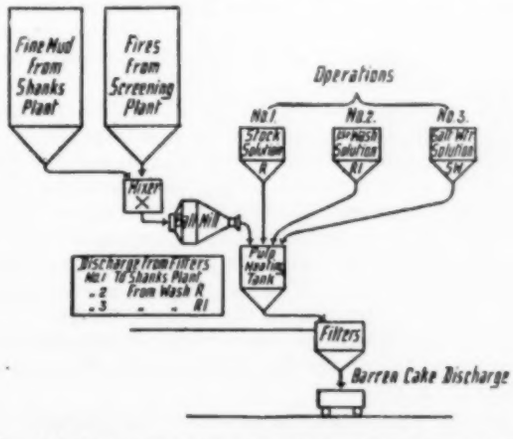


FIG. 1—DIAGRAM OF FILTER TREATMENT OF FINES AUXILIARY TO MAIN (SHANKS) PLANT—BUTTERS SYSTEM

would have to be concentrated in evaporators (a liquor generally considered good enough to go to the crystallizers will contain about 750 gr. per liter of nitrate of soda and 120 gr. per liter of salt, and have a density of 104 deg. Tw. at 102 deg. C.), separated from the insoluble salt, and crystallized in order to regain the nitrate, but the Butters process has not considered the necessity of evaporators so far. They prefer to use the process as an auxiliary to the existing system. The cakes are subsequently washed twice with weakening liquors; the washing is claimed to be by displacement only and the final wash is done with salt water (saturated brine) which leaves the cakes with about ¼ per cent nitrate of soda. The cakes are then discharged. The different liquors obtained from each successive displacement wash are used in the next round, the whole forming a cycle of operations, at one end of which the strong liquor is removed, while at the other end the cold brine "displacement" wash takes place.

As it is being used at present in Oficina Agua Santa, the Butters process acts as an auxiliary process to the main Shanks Maquina, and the results claimed so far are sufficiently good to restrict the working of the process to these lines.

The process, which has now worked there for nearly a year, consists in screening the whole of the crushed product in order to remove 20 per cent of it as fines passing a 6 mm. mesh. These fines are treated by the Butters process as described above.

The coarser material alone is treated in the boiling tanks, as formerly, and the liquors obtained from the Butters process are introduced into the cycle of operations in the Shanks system, the whole process being assisted by evaporators previously installed in the works.

By the combination of Shanks process, Butters fines treatment, and evaporators, material of 14.5 per cent nitrate content is worked successfully with an efficiency of 64 per cent as against an efficiency previously obtained by the Shanks process plus evaporators alone of about 50 per cent. Working costs appear to be fairly high, but in view of the increased yield of nitrate obtained from the same amount of raw material the combination of processes must be admitted to have met with success. As to what measure of this success is due to the Butters system alone it is difficult to state, as it is claimed that by the mere elimination of fines alone the lixiviation in the Shanks system is so very considerably improved as to increase the yield therefrom from 50 per cent to 61 per cent.

Without the use of evaporators it is doubtful whether any such improvement would be shown, and it is more doubtful still whether the strengthening up of the liquors produced by the auxiliary process by passing them over the coarse material in the Shanks system is a satisfactory way of using these liquors, without recourse to evaporation.

But it is certain that there is a limit to the amount of such liquor which could be strengthened up in this way, without evaporation. If it is assumed that 75 per cent of the total material is fine and the other 25 per cent coarse, the fines will contain 72 per cent of the total nitrate, of which 90 per cent will be extracted and made into weak liquor; the coarse will contain 25 per cent of the total nitrate only, of which but 65 per cent at the outside can be extracted in the Shanks Maquina. This means that there will not be enough nitrate available in the coarse to bring the liquors from the fines to crystallizing strength.

As the process stands at present it is claimed: (1) A 90-95 per cent extraction of nitrate from raw materials as low as 11 per cent in average and the ability to produce liquors which can be directly crystallized for their nitrate of soda content. (2) That this can be carried out at low labor and fuel cost. As we have pointed out, it has not so far been worked in this way, but only as an auxiliary process to the Shanks system combined with evaporators, in which combinations its actual success, cost of operation particularly, is obscured by other factors.

The process is still in course of trial and doubtless will be improved in many ways and eventually perhaps successfully applied to certain of the particular needs of the industry of the future.

GIBBS PROCESS

Early in 1912 Messrs. Gibbs & Co. of Valparaiso dispatched their engineer and chemist, the writers of this paper, on a tour of investigation through the U. S. A., France and Germany in order to gather as much information as was possible on methods used in other industries, so as to be able to develop the Chilian nitrate industry on more modern lines.

This resulted in the initiation of a process, on completely new lines, consisting of a new method of lixiviation and a process of evaporation which combined the regaining of the nitrate direct together with the separation of the sodium chloride. The details of the process were worked out in England, the theoretical part at the Manchester School of Technology, and later at the experimental laboratories of Messrs. G. T. Holloway & Co., and the practical part at the latter laboratories and near Mitcham, where an evaporation plant was erected on the principle worked out in conjunction with the Kestner Evaporator & Engineering Co., Ltd., of London. The results were completely satisfactory and a demonstration was given in July, 1914, before the representatives of the nitrate industry and the Chilian Ambassador and his suite.

The Gibbs process aims at the treatment of the raw material as two separate sections in the problem. (1) Lixiviation of raw material; (2) Concentration of liquors from 1; and No. 2 may be subdivided into (2a) Separation of salt contained in the liquors from 1; (2b) Separation of nitrate of soda.

The Gibbs treatment of raw material is based on the observation that in typical caliches, both of high and low grade, the soluble material is the binding agent by means of which a conglomerate of insolubles is held together.

This insoluble material consists of stones and sands together with finer matter such as clay, oxides of aluminum and iron, etc., which may be considered to be slime formers. (It is these slimes which prevent the free lixiviation of the mass and complete removal of liquors therefrom, and the removal of these slimes is the prime object of the Gibbs lixiviation scheme.) The stones and particles of sand, etc., are quite in their native state and are free from soluble matter with the exception of what is crystallized round them. If, in the laboratory, the raw nitrate-bearing material is treated without any grinding or breaking at all, with dissolving agents (hot water) in such a way as to wash out all of the soluble contents, the insoluble remainder, when ground to an almost impalpable state, will show practically no further trace of soluble matter. The results of the washing will be to produce a stony, sandy mass which is quite valueless for nitrate content.

A reference to the screening tests, Table I, on two extreme caliches will show what occurs after complete lixiviation.

It is on this principle of separation and removal of slimes during lixiviation that the Gibbs system of lixiviation is based and the objective is reached in practice

in the following way. The raw material is crushed as usual to about 2 in.-3-in. and fed into a mill together with nitrate solution at about 50 deg. C.

This mill, worked without balls or pebbles, acts purely as a disintegrating mill, in which the raw material is reduced to its ultimate particles with the minimum of grinding or sliming action.

The pulp is passed continuously from the mill to a series of classifiers in which the lixiviation action takes place in counter-current.

Assuming four classifiers in the series, water is fed into No. 4 where it washes the already thrice washed insoluble matter and the wash from this is passed forward to No. 3 which it washes and in turn is passed to No. 2 and finally to No. 1. The insoluble matter passes from No. 1 to No. 2 and onward to No. 4 whence it is discharged.

TABLE I—SCREEN TEST AND ANALYSIS OF CALICHES

Mesh	1 Mm.	% of Insolubles	A	B	Analysis	A	B
Plus	5	Sands and stones	21.75	45.30	Sodium nitrate	24.93	9.66
Plus	8	.....	8.39	9.10	Sodium chloride	25.30	9.87
Plus	10	.....	3.06	4.80	Sodium sulphate	2.20	8.27
Plus	20	.....	10.71	11.70	Mag. chloride	7.27	.....
Plus	30	.....	5.34	4.40	Calcium chloride	3.37	.....
Plus	40	.....	5.72	4.40	Calcium sulphate	.....	3.97
Plus	80	.....	12.21	5.60	Other solubles	10.73	1.00
Plus	100	.....	6.10	2.20	Total solubles	73.80	32.77
Minus	100	Sands	13.74	6.60	Insolubles	26.20	67.23
Minus	100	Slimes	12.98	5.90	Total	100%	100%

The object of the classification is twofold. In the first case the classification is for the separation of the slime-forming fines, together with a proportion of fine sand, in effect the washing off from the bulk of the raw material that portion of it which is about —80 mesh. In the second case, assisted by a rise of temperature to whatever is decided as convenient, solution of nitrate is brought about by intimate contact between wash liquors and particles of raw material.

The liquor coming from classifier No. 1 contains then all the —80 insolubles while the +80, together with adherent solution (from which it is drained as much as possible on its passage to No. 2 classifier) and undissolved nitrate, passes to No. 2 where it meets the weaker wash from No. 3. Slight classification may take place here, but essentially the function of this and the following classifiers is to bring the solid particles into intimate contact with the weaker liquors. The action takes place in four stages and the final insolubles, passing out of No. 4 stage or classifier, are in the form of clean sand, gravel, stones, etc., which do not contain, locked up in crevices in the particles, any more than ¼ per cent nitrate of soda. As the mass can be easily washed and drained the loss of nitrate in this part ought to be little more than that quantity. Having extracted the nitrate and disposed of the bulk of the insoluble matter, the liquor obtained from No. 1 is a saturated solution of nitrate and salt together with the other soluble salts and containing the —80 insoluble viz., fine sands and slimes.

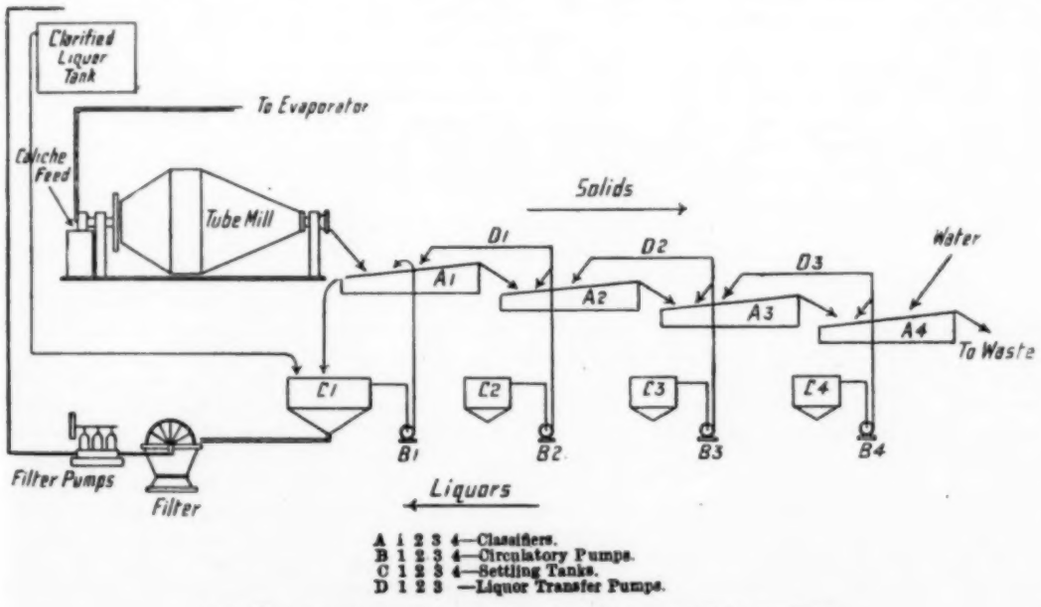
It will be noted that the classification aimed at is not the fine classification desired in most mining propositions, and the principal object, that of removing from the insolubles the fine portion, permits of the easy and cheap washing and disposal of the rest of the bulk. As will be seen from the screen tests shown (taking the classification as separating the + and —80 mesh) the amount separated as —80 will be in the case A 32.82 per cent of the insolubles or 8.6 per cent of the total raw material, and in case B 14.7 per cent and 9.88 per cent respectively, and these quantities have to be filtered out of the liquor obtained from No. 1 classifier. This filtration is carried out by means of the Oliver continuous vacuum filter, which is a revolving drum of which about one-third of the circumference at a time is dipping under the liquor to be filtered.

The drum is divided into segments which in turn are connected to vacuum and compressed air and the operation is mechanically controlled by means of a disc valve, the cake being sucked on by vacuum while that part is dipping into the liquor (kept agitated), sucked dry for part of the time it is out of the liquor, spray washed and dried also under vacuum, and finally scraped off after being loosened by compressed air.

The net result of the operations is that about 10 per cent of the raw material is treated by the more expensive filtration process while the rest of the insolubles, case A 17.6 per cent of the raw material, case B 57.32 per cent of the raw material, is washed quite free from its soluble nitrate contents and discharged without any filtration or expensive treatment. The advantage in the case of low grade material is obviously enormous.

The process has been designed to obtain a liquor containing about 450 grams of nitrate of soda per liter and about 200 grams of salt, with about 50 or 60 grams of other soluble salts, as calcium and magnesium sulphate, chloride, and nitrate, sodium sulphate, etc.

By increasing the temperature of operation a stronger liquor may be obtained, but this increase in strength by rise of temperature is subject to economic limitations which it is intended shall be studied on the large scale on the spot.



A 1 2 3 4—Classifiers.
B 1 2 3 4—Circulatory Pumps.
C 1 2 3 4—Settling Tanks.
D 1 2 3 —Liquor Transfer Pumps.

FIG. 2—GIBBS PROCESS. DIAGRAM OF LIXIVIATION SYSTEM

The actual experiments on the large scale show the losses to be approximately ½ per cent nitrate on the +80 mesh and 2 per cent nitrate on the —80 mesh, or out of 1000 tons caliche A (24.93 per cent):

262 tons insolubles would contain 86 tons slimes at 2% = 1.72 tons
262 tons insolubles would contain 176 tons coarse at ½% = 0.88 tons
2.60 tons

Out of a total of 249.3 tons nitrate of soda hence 246.7 tons is recovered or 98.9 per cent yield.

In case B—

1000 tons of material 9-66% nitrate:
98.8 tons slimes at 2% nitrate = 1.976
573.2 tons coarse at ½% nitrate = 2.866
4.842 tons nitrate

Out of a total content of 96.6 tons nitrate of soda the yield is 91.758 tons or 95 per cent.

As mentioned above, the standard liquor aimed at in the lixiviation system above outlined contains nitrate of soda 450 grams per liter, salt 200 grams, other solubles 50 grams, water 650 grams; total 1350 grams per liter.

The evaporation system is divided into two sections, one aiming at the almost complete separation and recovery of the salt, while the other recovers the nitrate of soda direct in the form of crystals.

In the first part the evaporation is carried out as a double effect. In the lower temperature effect the evaporation is done under vacuum at about 80 deg. C. and the liquor from this goes to the second, the higher temperature effect, for evaporation at about 124 deg. C. under normal atmospheric pressure.

At this temperature practically the whole of the salt is rendered insoluble and the plant, a modification of the well-known Kestner evaporator, is arranged so as to insure the transference of the desalted liquor without loss of temperature (and consequently nitrate of soda) and completely free from suspended salt, to the nitrate crystallizer, which is a vacuum effect without calandrias.

Here by cooling and self-evaporation under vacuum the nitrate crystallizes immediately and is removed from the coded bottom by a screw and dried in hydro-extractors. The apparatus is shown in accompanying figure and works approximately as follows: Effect No. 1, which is worked under a suitable vacuum, causes the deposition of about 50 per cent of the total salt contents of the liquor. This salt is removed by a mechanical screw and sucked dry and washed in a vacuum filter. The liquor from No. 1 passes to No. 2 where the maximum temperature desired is reached. This brings about the completion of the desalting and the liquor, now boiling at or about 124 deg. C., is transferred to No. 3, a vacuum effect without calandrias where the nitrate is deposited.

The salt from No. 2 effect is periodically removed by means of the specially designed filter box, which permits of the salt being washed after draining and disposed of with the minimum loss of nitrate of soda. The steam produced in effect No. 2 is used for procuring the evaporation in No. 1 and all surplus steam is diverted to a preheater or to the lixiviation plant.

The advantages claimed by the Gibbs process are: 1. Cheapness of installation. 2. Ability to treat cheaply and effectively low ley caliches with an efficiency of 90 per cent extraction over all. 3. Ease of control of process. 4. Direct crystallization of nitrate, insuring ability to trace losses and remove their causes almost at once. 5. Greater control over the working of the nitrate deposits.

Advantage No. 5 should give an incentive to the development of the mining of nitrate of soda. Many causes, chief among which is the necessity for hand selection of the material used today, have conspired to prevent the development of the use of mechanical drills and shovels in the Chilean nitrate fields.

It is to be expected that with the advent of the newer processes no longer necessitating the specially hand selected material, these causes will automatically disappear and the more rational mining come into its own.

The mother liquor from the hydro-extractor is periodically examined for lime and magnesia content, and treated for the conversion of these into sodium salts when necessary, separated from the insoluble magnesia and lime, and returned to the system, being introduced into either the high or low temperature effect according to circumstances. Periodically the accumulated iodine salts will be examined and the iodine extracted by precipitation in the usual way.

The cost of a complete installation of the Gibbs process is estimated to be about one-half that of the present type of plant, and it is expected to be able to treat material of as low a ley as 10 per cent with 90 per cent efficiency, at a cost reduced in a marked degree. There can be no comparison of costs when working with 10 per cent material with the Gibbs process because the present type of plant cannot deal with it at all.

The first Gibbs plant is now being constructed for the Fortuna Nitrate Co. for their Oficina Celia, Antofagasta, Chile, and it is expected to commence actual work within the next nine months.

Synopsis of Recent Metallurgical and Chemical Literature

Blast Furnace Plant

Power Plants for Blast Furnaces and Steel Mills.—In a paper presented before the Engineers' Society of Western Pennsylvania and printed in the *Proceedings* of the society for March, 1917, RICHARD H. RICE and SANFORD A. MOSS, engineers of the General Electric Company, Lynn, Mass., discuss the turbo-blower for supplying blast, and give a cost comparison of a power plant using these blowers and one using gas engines. They state that the use of turbo-blowers for blowing, and of turbo-generators for generating electric power for steel mills from surplus gas gives a type of power plant which is competitive with a plant using gas directly in gas engine-driven blowers and generators. Complete tabulations of the cost of operation of each type for four blast furnaces are given. The first costs are found, and from them are computed the fixed charges at the rate of 13 per cent. To this is added running charges and cost of make-up coal. A small amount of make-up coal is used in the gas-engine plant to equalize poor gas and excess power demand, and a somewhat larger amount is used in the turbine plant. The authors claim that the gas plant first cost is about two and one-half times the steam turbine plant first cost, so that, taking account of fixed charges, the total operating cost of the gas plant is about twice that of the steam turbine plant. They state that this item of first cost is so influential that, regardless of exact details used in comparisons, a steam turbine plant will always turn out to have lower total charges than a gas-engine plant if fixed charges are included. An extended discussion by representative engineers from large steel companies, gas engine and equipment companies follows the paper, and differing opinions are given as to the value of the turbo-blower in the blast-furnace plant.

Melting of Metals

Melting of Brass.—At the meeting of the Institute of Metals in London the latter part of March, several papers were presented on the melting of non-ferrous metals. One of these abstracted in *Iron and Coal Trades Review* was on the melting of brass, describing a new furnace. The authors are H. M. THORNTON and HAROLD HARTLEY. The furnace referred to is a Richmond 70-lb. gas-fired crucible furnace of the preheating type. The gas and air mixture is admitted through a suitable blast burner and the lower portion of the combustion chamber, and is burnt in the annulus between the crucible and the furnace wall. The gases, after traveling around the pot, are directed through the metal preheating chamber, and then pass on to the air pipes, and finally to the flue. This arrangement enables a high degree of preheat of the metal to be obtained. The top of the metal chamber is on a level with the top of the pot chamber, and is closed by a pair of lids. With this construction the operator has not to lift his metal above the foundry floor level, and the transference of preheated material to the crucible is done with ease. The lower portion of the wall of the combustion chamber is constructed of suitably shaped blocks of a specially refractory nature to enable greater resistance to be offered to the combined action of high temperatures and spilt metal. The bottom of the chamber can be removed for the recovery of spilt metal. In regard to cost of operation the authors have the following to say:

"In working with coal-gas the fact must not be overlooked that in terms of B.t.u. available the fuel is costing from four to five times as much as coke, assuming the gas supply to give 500 B.t.u. per cubic foot net at a cost of 2s. per 1000 cu. ft., and even with water-gas the fuel is considerably more costly per B.t.u. than the coke which it is intended to replace. Starting with this disadvantage the furnace manufacturer has either to obtain a markedly greater thermal efficiency out of his appliance, or to effect economies in other directions." They have used in their work with brass and copper a pouring temperature about 100 to 150 deg. above the liquidus. The following table gives the results of six melts, representing a typical run:

	Gross Consumption per Lb. Metal Melted, Cubic Feet	B.t.u. per Lb. Metal Melted
Average for 6 melts	2.25	1203
Average for 12 melts	1.92	1031
Average for 15 melts	1.86	996
Average for 20 melts	1.79	962

From rough calculations it was determined that the thermal efficiency of gas furnace is five times that of the coke furnace. Increased life of pots and increased output are also important factors.

Melting Metals in the Electric Furnace.—A paper on this subject was read at the March meeting of the Institute of Metals (London) and abstracted in the *Chemical Trade Journal and Chemical Engineer*, March 24, 1917. The authors are H. C. GREENWOOD and R. S. HUTTON. The authors have had occasion to note the great improvement in working qualities of nickel-silver alloys melted with gas over similar alloys melted with coke. Electric heating should show an even greater advantage. For non-ferrous alloys a construction of furnace suitable for using ordinary crucibles is especially desirable. The electric furnace designed by the authors takes a 100-lb. plumbago pot. The electric heating is quite independent of the crucible, the furnace being of the "resistance" type, the current passing through upright carbon rods situated near the inner face of the walls of the furnace; the heating is thus under perfect control. Actual tests carried out with a charge of 90 lb. of nickel-silver took three hours for the first heat and one hour and thirty-five minutes for the second heat; the energy consumption was 53.6 and 29.2 kw.-hr. respectively. The principle advantages to be expected from electric heating are: (1) Absence of gas currents, reducing spelter losses and making the maintenance of a reducing atmosphere relatively simple; (2) lower sulphur contamination; (3) greatly enhanced life of crucibles; (4) improved quality of metal. The further development of this furnace was postponed owing to the difficulty of obtaining carbons in this country at the commencement of the war. A description of the work in its incomplete form is, however, given with the object of encouraging others to devote their attention to the development of a commercially practical electric furnace.

Melting Metals with High-Pressure Gas.—Recent practice in England in the use of high-pressure gas for metal melting is described in a paper of C. M. WALTER, read at the Institute of Metals meeting. An abstract is given in *Iron and Coal Trades Review* for March 23, 1917.

The application of town gas for the melting of brasses, bronze and other alloys has during the last few years received considerable attention, and at the present time, in many localities where gas can be obtained at a reasonably low rate, it is being largely used with considerable economy in melting costs. Many excellent types of furnaces are now obtainable, and crucible furnaces having pot capacities from 50 lb. to 800 lb. are now commonly met with. Such furnaces may be classified into three distinct groups, according to the manner in which the gas is applied, as follows:—A. Furnaces designed for working with gas at the ordinary town pressures of 2 to 3 in. water-gage, and fitted with atmospheric burners. B. Furnaces employing gas at ordinary town pressures with air under a positive pressure of usually 1 to 3 lb. per square inch. C. Furnaces in which gas is employed at a pressure considerably higher than the ordinary pressure, and fitted with either—(*a*) atmospheric burners; or (*b*) burners designed for working with air under a moderate pressure of about 20-in. water gage. Under heading C, which comprises the furnaces specially dealt with in this paper, there are the following classes: (1) (*a*) Pit furnaces for melting brasses and bronzes for sand-castings, ranging from 60 to 200 lb. capacity; (2) pit furnaces for melting brasses, bronzes, and cupro-nickel, for strip and billet castings having pots of capacities up to 200 lb.; (3) pit furnaces for melting aluminum alloys, having pots of capacity 200 to 600 lb. (copper); (4) small furnaces for melting precious metals having pots of capacity 10 oz. to 200 oz.; (1) (*b*) furnaces for melting brasses, bronzes, pure nickel, and for melting non-ferrous metals generally where extremely high temperatures and high speeds of melting are required. An equally important application of the use of high-pressure gas is in connection with the melting of aluminum and its alloys, and for the production of fine quality castings and high-tensile alloys of this metal; owing to the cleanliness, convenience and ease of temperature control, the high-pressure gas furnace may be said to have firmly established itself in this connection on the score of both efficiency and economy. For the melting of such alloys an a large scale, the furnace usually employed is one constructed on similar lines to those already described, heated by means of high-pressure injector burners, with gas at a working pressure of about 12 lb. per square inch. These furnaces are usually built to take pots of capacity 500 to 600 lb. (cop-

per), the metal being ladled from the melting-pots into smaller pots for carrying to the molds. With such plant it is found that, in the case of the melting of the ordinary commercial aluminum alloys, during a working day of twelve hours 10 heats of metal of about 200 lb. each can be obtained from each furnace, with a gas consumption of 12,000 to 14,000 cu. ft. per ton of metal melted.

Coal-Gas for Melting Non-Ferrous Alloys.—The results of tests on coal-gas as fuel were described in a paper read by GEORGE B. BROOKS at the Institute of Metals meeting in London. An abstract is given in *Iron and Coal Trades Review* for Mar. 23, 1917. The results are summarized in the following questions:

(1) Would ordinary coal gas give a temperature that was sufficiently high for casting cupro-nickel?—No difficulty at all was experienced in attaining a temperature of 1400 deg. C.

(2) What was the relation between the coke-fired furnace and the gas-fired furnace from the following standpoints?—

(*a*) *The Relative Cost of Melting Per Ton of Alloy Produced.*—Average cost of melting with high-grade metallurgical coke, 36s. 4d.; with gas at ordinary Sheffield rates (1s. 9d. per 1000 cu. ft.), 31s. 9d.; at the preferential rate allowed for gas engines (1s. 4d.), 24s. 2d.

(*b*) *Relative Speed of Melting.*—It was under this heading that the great advantage was shown by gas over coke. The same weight of metal (56 lb.) can be melted in the gas furnace in 52 minutes which required 82 minutes in the coke-fired furnace. When this advantage is translated into commercial practice, the advantage is still more striking; for on the two-day test with the gas furnace it was possible to obtain 12 heats in less than ten hours, whereas in an ordinary working day of ten hours it is rarely possible to get more than five heats from a coke-fired furnace.

(*c and d*) *The Life of the Crucibles and the Wear and Tear of Lining and Burner.*—Graphite crucibles of the same make have a longer life in properly controlled gas-fired furnaces than in coke furnaces (average 17.6, as against 12.5 heats). The lining of the furnace stood the test satisfactorily, and the condition of the burner was also quite good.

(*e*) *Mechanical Losses.*—The percentage loss was found to be 0.40, which represents a substantial saving compared with coke furnaces (1 per cent with the best practice).

(*f and g*) *Labor and Capital Charges.*—The labor charges per ton of metal produced would be less with the gas-fired furnace in a large installation from the fact that a larger number of gas furnaces can be controlled by the same staff, and the output would be higher in the case of such furnaces. There would be very little difference in the capital cost of an equal number of furnaces of the same output.

(*h*) *Quality of Product.*—The cupro-nickel was tested at every stage, and was found to be satisfactory. The ultimate test in the actual production of bullet sheaths showed that the material was equal, if not superior, both as regards quality and number of failures, to any that had been produced in coke-fired furnaces.

The absence of ashes, the elimination of the wasteful process of "slagging," the economy in fuel under control, the reduction of impurities in the fuel, and the speed of melting are factors of considerable importance to the manufacturer.

Metal Melting at the Mint in England.—A paper presented before the recent meeting of the Institute of Metals by W. J. HOCKING describes the melting of gold, silver, bronze and cupro-nickel. An abstract is given in the *Chemical Trade Journal and Chemical Engineer*, Mar. 24, 1917. The castings are about 2 ft. long and varying in width and thickness. Small charges are used, for gold-copper about 2800 oz., and for silver-copper about 6000 oz. For bronze and cupro-nickel about 400 lb. are used. Coke furnaces were in use until 1910. The melting department was then enlarged and rebuilt, and, as the result of a series of experiments, furnaces, fired by low-pressure gas and air, were introduced. Urgent demands for gold coinage arising during the rebuilding operations, an improved gas-melting plant was installed in a disused smithy with a floor space of 860 square feet only. In the course of a year and nine months 874 tons of standard gold, amounting in value to 111 millions sterling, were melted. As a test of the efficiency of the four experimental furnaces in use, a continuous run of melting was maintained for 27¾ hours. The total amount of gold melted was 257,052 oz., or 7.87 tons, which is upwards of a million sterling in value. There were 102 pourings, and the consumption of gas was 32,000 cubic feet. The furnaces were in a condition to resume work on the following day as usual. The furnaces in the new buildings are designed to burn gaseous fuel, gas being supplied at 3-in. pressure and air at 2½-lb. pressure. The burner adopted is of the Brayshaw type, with a specialized form of attachment to the furnace. Two sizes of furnaces were constructed in separate rooms, one for melting gold with crucibles of a capacity of 2800 oz. and one for other metals with crucibles taking 400 lb. The large furnaces are sixteen in number, and are built of Stourbridge firebrick, each well being 19 in. in diameter and 32 in. deep. The wells are lined with circular firebricks, 3 in. thick, jointed with a refractory material composed of carborundum, firesand, and silicate of soda. The furnaces are constructed in line towards the center of the room, and arranged in two batteries, one of ten and one of six. The brickwork is braced together by a framework of iron bars to resist expansion, but is not enclosed with iron casing. The tops, however, are covered with cast-iron plates 1 in. thick, bedded upon a half-inch layer of asbestos cement. The rate of gas consumption by the sixteen large furnaces is about 15,000 cubic feet per hour. A six-inch service pipe is used for delivery, and this provision is well in excess of the requirements, an ample reserve being considered essential in order to obtain uniformity in results. Records of the costs incurred under the two fuel systems are available for comparison for extended periods. During five years, 1911-16, coinage metals to an amount of 9900 tons were melted with a total gas consumption of 121 million cubic feet. The average consumption per ton melted was 12,200 cubic feet, and the cost of the gas was 20.58 shillings. The general results showed that with this fuel, as compared with coke, the rate of output was more than doubled, the greatest increase occurring in the case of metals with high melting points. Substantial economies were also made in the actual cost of fuel, of graphite goods, and of labor. The total economy effected under these three heads was at the mean rate of 25 per cent.

Carbides

Researches on the Carbides of Aluminium, Copper and Nickel.—In the July-August number of the *Revue de Metallurgie*, 1916, pp. 155 to 156, is given an extract of some work on aluminium, copper and nickel carbides by BRINER and SENGLET. Aluminium carbide heated in

air decomposes according to the equation $Al_4C_3 + 6O_2 = 3CO_2 + 2Al_2O_3$. In the absence of air the product dissociates according to the following equation $Al_4C_3 \rightleftarrows 4Al + 3C$. In this last case the quantity of aluminium found after the reaction will always be less than the theoretical amount due to a loss by volatilization and by the formation of aluminium slags or other compounds by the attacking of the receiver in which the material is heated. Concerning the reaction velocity the authors obtained the following results:

Heating Time in Hours	Temperature	Per Cent
Dissociation in Air		
7 hr. 00 min.	900 deg. C.	100
1 hr. 30 min.	900 deg. C.	99.5
2 hr. 30 min.	900 deg. C.	98
1 hr. 40 min.	700 deg. C.	95
2 hr. 30 min.	540 deg. C.	85
Dissociation in Vacuum		
1 hr. 00 min.	540 deg. C.	22
1 hr. 30 min.	540 deg. C.	42
4 hr. 00 min.	540 deg. C.	70

According to these figures the decomposition is not proportional to the time or the heating. The authors claim this to be due to the nature of the reaction and to the heterogeneity of the surroundings. In the first case the reaction velocity depends a great deal upon the ease with which the oxygen has access to the reaction components. From the above it may be seen that the velocity of decomposition at 540 deg. C. is greater in the presence of air than in vacuum. The opposite is the case with such carbides as calcium carbide heated to 900 deg. C.

To show that the reaction $Al_4C_3 \leftrightarrows 4Al + 3C$ is reversible, the authors endeavored to prepare the carbide under the same conditions as were used for the decomposition of the carbide. On heating powdered aluminium in vacuum with a large excess of powdered sugar carbon at 500 deg. C. for two hours only minute amounts of carbide were formed. At 750 deg. C. a slight formation of carbide was observed. At 900 deg. C. the reaction was practically complete. The reaction therefore is reversible. In equilibrium, the system consisting of aluminium carbide, aluminium and carbon shows the presence of the carbide at low temperatures and the elements aluminium and carbon at high temperatures.

The carbide of nickel used in the tests was made by heating very pure nickel on a bed of sugar carbon enclosed in a graphite crucible in an arc furnace. After fusion the product is poured into cold water or into an oiled mold. The product thus obtained on treating with hydrochloric acid does not evolve gaseous hydrocarbons, nor are liquid or solid hydrocarbons formed. Hydrogen is given off and some graphite is formed. Chemical analyses gave no results and recourse had to be taken to microscopic studies. The prepared samples were dipped into concentrated nitric acid for ten seconds and then examined. According to the metallographic examinations the carbide of nickel is formed according to the equation $3Ni + C = Ni_3C$ under conditions of maximum concentration and a temperature in the neighborhood of 2100 deg. C. At lower temperatures the carbide regresses to its constituents. This latter phenomenon takes place rapidly at 1600 deg. C. and is retarded greatly in the vicinity of 900 deg. C.

Similar tests as were run on nickel carbide were made on copper carbide. Copper heated with sugar carbon at very high temperatures gave a carbide which was investigated. It would seem that at high temperatures a carbide is formed endothermically which rapidly dissociates into its constituents at 1600 deg. C. The decomposition velocity then decreases as the temperature decreases.

Recent Metallurgical and Chemical Patents

Oxygen and Hydrogen

Electrolytic Oxygen and Hydrogen Apparatus.—Improvements on an apparatus previously patented are the subject of another patent by R. J. J. MUELLER and E. G. ROWLANDS, of Sheboygan, Wisconsin (assigned to the Universal Oxygen Company, a Wisconsin corporation). The previous patent was abstracted in our issue of April 15, 1917, page 453. Among the improvements aimed at in the present patent are changes in the tank and diaphragm-frame construction. The wooden frame previously described is here replaced by a special member, which is also part of the tank itself and is insulated from both positive and negative poles. An improved method of suspending the diaphragm is described, also a closed bottom for each diaphragm and a trough-shaped member in the bottom of the diaphragm which serves as a receiver and retainer of scale and oxide dust dropping from the anode. Other improvements are changes in the anodes and in the bottom of the tank, which is enlarged and provided with a trough-shaped lining to cut off all electric action or flow of current from the bottom of the tank to the anodes; improved means for flushing or cleaning out the tank; means for inspection of the interior of the tank during operation; improved hermetic sealing-devices to prevent escape of gas to the open air and also of hydrogen to the oxygen chamber, or vice versa. 1,220,262, Mar. 27, 1917.)

Aluminium

Aluminium from Aluminium Carbide.—An electric furnace process of reducing aluminum carbide is patented by PAUL R. HERSHMAN, of Chicago, Ill. (Assigned to the Mineral Products Company of New York City.) Aluminium carbide mixed with 10 to 20 per cent by weight of aluminium oxide, chloride or sulphide is charged into a vertical electrical furnace which is designed to operate under pressure maintained by a safety valve, and in the presence of a suitable gas. A temperature of about 2100-2200 deg. C. and a pressure of 10-15 lbs. per sq. in. are used in the reduction. An oxide, chloride or sulphide of another metal may be added. In this case the proportion should be such that the eutectic alloy of aluminium and the other metal is formed. Thus with copper the alloy would be figured on, which would contain 94.2 per cent of aluminium and 5.8 per cent of copper. (1,220,843, Mar. 27, 1917.)

Furnace Construction

Combined Fuel and Electrically Heated Refining Furnace.—A refining furnace heated by both fuel gas and electricity is patented by ALOIS HELFENSTEIN, of Vienna, Austria-Hungary. In order to overcome the necessity for inserting electrodes each time the electrical heating is to be used, a long horizontal tubular furnace is used, with a metal bath which is shallow relative to the diameter of the furnace. An end view and longitudinal view of this furnace are shown in Fig. 1. The furnace is charged through openings 2 with fluid or cold charge and additional substances and receives the heating gas for carrying out the normal Martin process through the generator 3. In the bottom of the furnace the tube has inserted poles 4 through which the current from the dynamo engine or from a division of a transformer secondary current circuit can be transmitted at any time to the bath 5. The poles consist of first-class conductors, are water cooled and inserted so that they come into direct contact with the metal bath, and are connected outside the furnace with the source of current, but notwithstanding their arrangement are situated outside the fuel heating zone, and are thus not exposed to

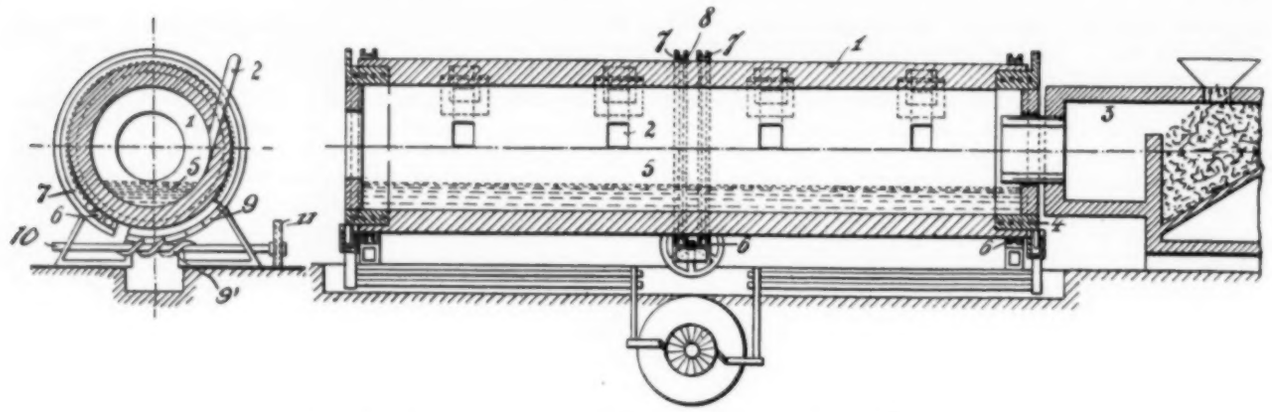


FIG. 1—FUEL AND ELECTRICALLY HEATED REFINING FURNACE

the high temperature. The tubular furnace is seated on rollers 6 and can be swung and rotated around its axis by a driving mechanism. (1,220,111, Mar. 20, 1917.)

Method of Making Furnace Hearths.—A method of making furnace hearths adapted to electric furnaces of the Heroult type and also to open-hearth or other metallurgical furnaces is patented by JAMES H. GRAY, of New York City. In the ordinary method of making hearths in electric furnaces a complete bottom of magnesia with a tar binder is rammed in cold and then fritted in place by placing a layer of coke on the bottom and passing current through by lowering the top electrodes. The fritting only penetrates for a few inches, leaving the lower part of the bottom still in the granular condition. In this condition the hearth is easily destroyed when the fritted surface breaks through. In the present patent it is proposed to introduce the bottom material in a molten or semi-molten condition, taking advantage of the fact that magnesia and similar materials are fairly good conductors of electricity at high temperatures. The procedure in making a hearth of magnesia or calcined magnesite in a Heroult furnace is given as follows:

"I first place a layer of magnesia bricks on the bottom of the shell of the furnace and then place a layer of granular magnesia one or two inches thick on the bricks. I then heat the furnace and the magnesia to such a temperature that the latter becomes a good conductor of electricity. This may be done in any one of several ways. For example, a flame furnished by fuel oil may be introduced into the furnace, or a bed of coke may be laid on the magnesia and the electric current passed through the coke from the electrodes in the manner above described to heat the same to incandescence, or lengths of electrodes may be laid on the bottom and the regular electrodes lowered to strike arcs therewith and to pass an incandescing current through these special lengths. Any one of these methods will bring the main electrodes to a white heat and will furnish sufficient heat in the furnace to bring the magnesia to a temperature at which it becomes a sufficiently good conductor of electricity. When this temperature is reached the electrodes are lowered to the bottom of the furnace (removing any coke or similar material which may have been introduced for the initial heating) and arcs are struck between the electrodes and the now conductive magnesia. The arcs and the current passing through the magnesia increase its temperature until it becomes molten or semi-molten or pasty. When this condition has been obtained more magnesia in granular form is introduced about the electrodes and this in turn becomes conductive as it receives heat both from the electric arcs and from the heated walls and atmosphere of the furnace. As the material banked about the electrodes becomes conductive the electrodes are gradually raised so as to maintain the necessary resistance at the arcs for the desired number of amperes of current to flow through the electrodes, the raising of the electrodes being accomplished either by hand or by automatic regulators such as are now generally employed for regulating the height of electrodes in such furnaces. The hearth is thus built up to the desired depth and shape in a sound and reliable monolith, by throwing in new material progressively at such points as may need building up."

One of the chief features of the method is the comparatively short time required. It is stated that for an open-hearth only 12 hours is required as compared with one to two weeks by older methods. (1,220,839, Mar. 27, 1917.)

Blast Furnace

Preheating Blast-Furnace Gases.—OTTO OESTERLEN, of Zweibrücken, Germany, patents a process of preheating blast furnace gases before dry cleaning, in which part of the gases are withdrawn, burned in a furnace and used to heat a preheater through which the gases pass. The part of the gases withdrawn for burning may be taken before the gases have passed through the preheater or afterwards. The gases after passing through the preheaters are filtered and an auxiliary preheater may also be used after filtering the gases. It is claimed that this method is more economical than preheating with steam, and the preheaters can be kept smaller on account of the high initial heat contained in the burnt gases. (1,219,852, Mar. 20, 1917.)

Sulphuric Acid

Manufacture of Sulphuric Acid.—Improvement in the manufacture of sulphuric acid by subjecting the gas at various points in the process to an electric discharge is the subject of a patent of WILLIAM J. KEE, Jr., of Kansas City, Kan., and UTLEY WEDGE, of Ardmore, Pa. The gas leaving the Glover tower, consisting of a mixture of sulphur dioxide, oxygen, nitrogen and nitrous gases, is passed through a flue or chamber in which an electric discharge is maintained. This causes a combination of nitrogen and oxygen, the conversion of low oxides of nitrogen to higher oxides of nitrogen, and the formation of ozone. Sulphur dioxide is oxidized to sulphur trioxide by both the ozone and the high oxides of nitrogen. As a result of these reactions the formation of H_2SO_4 in the presence of steam is more rapidly effected than in the ordinary process, and the consumption of nitric acid or nitrate of soda used is much reduced. The electric discharge may take place at other points, i. e., the gas coming from pyrites or sulphur burners could be immediately subjected to the electrical discharge, but the conditions here would not be so favorable on account of the high temperature causing dissociation of the ozone and higher nitrogen oxides. The treatment might take place inside the Glover tower or even in the Gay Lussac tower. (1,220,752, Mar. 27, 1917.)

Bureau of Mines Station in Idaho.—The Bureau of Mines has entered into a co-operative agreement with the University of Idaho, whereby an ore-dressing experiment station is to be located at Moscow, Idaho.

Electric Steel Progress in England

The adoption of the electric furnace for steel melting by the Sheffield steel trade continues to make rapid progress and the new Greaves-Etchells type of furnace, built by T. H. Watson & Co. (of Sheffield), Ltd., has an increasing share in this activity.

Kayser Ellison & Company, Ltd., Carlisle Works, Sheffield, have placed an order for a 10-ton Greaves-Etchell's furnace, in addition to the one of 30 cwt. (1½ ton) capacity, which it is expected will soon be running.

One furnace of the same type of 3 tons capacity has been ordered by J. H. Andrew & Company, Ltd., Toledo Works, Sheffield, and 30-cwt. (1½ tons) furnaces have also been ordered by Thomas Andrews & Company, Ltd., of Sheffield, and Accles & Pollock, Ltd., of Birmingham.

A small furnace of the Greaves-Etchells type at the works of Spear & Jackson, Ltd., Sheffield, has now made over 1050 heats of high-speed steel and the lining has only once been renewed. A further larger furnace of this type was successfully started for this firm in March; also a furnace at Samuel Osborn & Company, Ltd., Sheffield.

According to T. H. Watson & Company (of Sheffield), Ltd., the owners of this furnace design, a number of additional furnaces will be installed as soon as consent is given by the Ministry of Munitions. The number already at work or about to be installed exceeds twenty.

One of the chief claims made for the Greaves-Etchells furnace by its makers is that it can readily melt the whole of its charge in the shape of shell turnings, etc., while it is claimed that in other furnaces only a limited quantity of turnings can be used new raw materials, pig iron, etc. The best place for the erection of a Greaves-Etchells furnace is, therefore, wherever there is an accumulation of turnings or steel scrap and a supply of electric current.

Palladium-Gold Crucibles as Platinum Substitutes

The high price of platinum (at present over $100 per ounce for the pure grade) due to the difficulty of obtaining it from Russia has given impetus to the search for platinum-bearing ore in our own country and to the search for platinum substitutes. Considerable research has been conducted on alloy substitutes, several patents have been granted and use has been made of research undertaken in previous years.

A Los Angeles, Cal., firm has recently brought out and is distributing through the large laboratory supply houses an alloy of gold and palladium called "Palau," which is claimed to be even more than a platinum substitute—namely in some respects an improvement on ordinary platinum. A laboratory crucible and cover made of this alloy were tested by the Bureau of Standards at Washington from whose report the following data are taken.

"In general appearance the ware had nearly the surface color of pure palladium and was quite similar to, but slightly darker than hammered platinum. The crucible was fairly rigid, being not so easily deformed as a pure platinum crucible and not so stiff as a crucible made of platinum with about 8 per cent to 10 per cent rhodium."

The specific gravity at 4 deg. C. was found to be 17.22 and the melting point 1370 deg. C. The electromotive force against pure platinum at 960 deg. C. was 8.5 millivolts and at 860 deg. C. was 7.2 millivolts.

To compare with previous observations on platinum crucibles the heating and treatment with dilute acid were carried out as follows:

The loss in weight of the crucible due to heating was determined in a furnace free from metal vapors such as described in Bureau of Standards Scientific Paper No. 254.

This crucible was heated at 1200 deg. C. for two periods of four hours each and weighed before and after each heating. The weighings to determine the loss due to heating were followed by treatments for five minutes with boiling hydrochloric acid (1HCl to $4H_2O$) and the loss in weight due to the acid treatments was determined. The solutions obtained from this crucible contained less than 0.01 mg. of iron as Fe_2O_3 determined by oxidizing the solution with bromine water, precipitating as hydroxide, filtering, igniting and weighing.

The summary of the Bureau of Standards is as follows:

"These tests indicate that the 'Palau' crucible, as far as resistance to loss on heating to 1200 deg. C. is superior to platinum containing about 2.4 per cent iridium, and somewhat inferior to platinum containing about 0.6 per cent iridium. The comparative freedom from iron is an improvement over most platinum ware now in use. It compares favorably with platinum in resistance to hydrochloric, nitric, hydrofluoric and sulphuric acids, ferric chloride and sodium hydroxide solutions and fused sodium carbonate. The 'Palau' crucible is not as suitable for potassium pyrosulphate fusions as platinum. For fusions with sodium carbonate and sodium nitrate the 'Palau' crucible is less attacked than platinum, but both wares are very seriously attacked under the conditions of our test, the fusion mixture containing no oxidizable material.

"The solubility of platinum is recognized and its elimination is provided for in exact methods of analysis. With the 'Palau' ware two metals, namely gold and palladium, may pass into solution, requiring somewhat different treatment for their elimination."

An interesting fact stated by the makers is that the ware will not wet; that the meniscus is downward as in the case of mercury.

Hydraulic Asbestos Press

The forming of fireproof shingles from an asbestos mixture can be accomplished by the use of a hydraulic press. The hydraulic press illustrated by Fig. 1 was originally designed for this purpose, but is also adaptable for other similar forming operations. It is a new design made by The Hydraulic Press Manufacturing Company, Mount Gilead, Ohio. The press was built for Japanese export trade, and will be used for forming asbestos shingles 42 in. square. The asbestos after being thoroughly mixed with other ingredients is formed into layers and placed upon drainage plates. Each plate consists of a steel plate, a sheet of woven wire and a sheet of duck cloth. A number of these plates with a layer of the mixed material to be pressed on each are stacked upon a steel truck which is then run into the press to receive the pressure for the purpose of extracting the excess moisture and to form each layer to a uniform thickness. The ingredients are also thus pressed into a solid mass. The formed slabs can be used in their original size, 42 in. square, or may be sawed into smaller pieces.

All of the operations of this press are controlled by one 2-in. four-way poppet operating valve. The press has two small push cylinders which return the main pressure ram after the pressing operation has been completed. These are mounted upon the base of the press

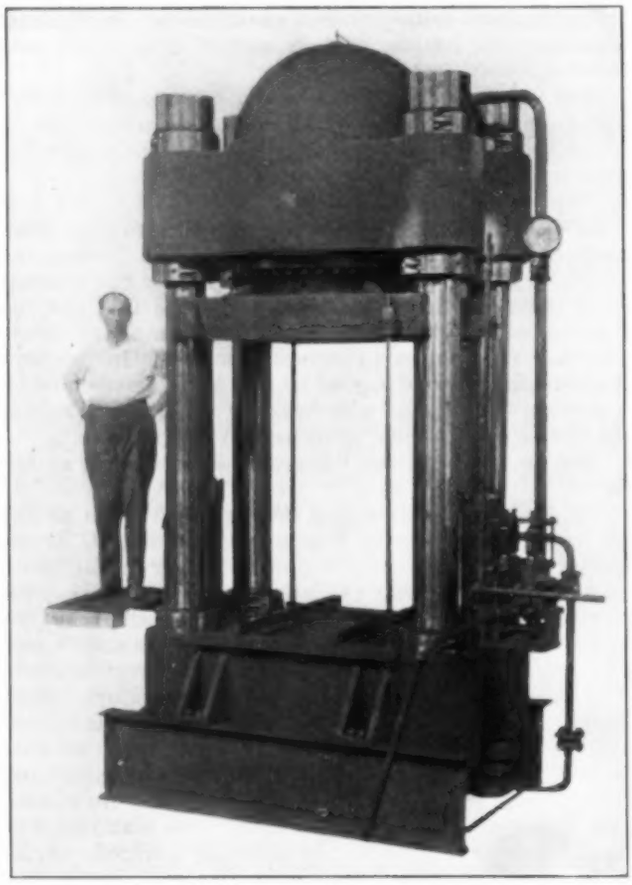


FIG. 1—42-IN. X 42-IN. X 6-IN. X 18-IN. RUN, 1500-TON INVERTED ASBESTOS SHINGLE PRESS

between the strain rods. The push rams have a diameter of 5 in. and a run slightly greater than that of the main pressure ram.

The track running through the press is not attached to the base of the press, but is mounted on a frame which is supported from above by four rods working through lugs cast on the platen. These rods have lock nuts on their upper ends by which the rods are adjusted to support the track at its proper level. When the platen is at its highest point, the track is lifted a short distance from the pressure bed. As the platen travels downward, the track is lowered upon the pressure bed and the platen continues to travel over the rods which pass through the bearings in the platen lugs.

The wheels of the truck are so mounted that the bottom of the truck is slightly below the bottom of the track. When the platen starts down, it lowers the four supporting rods with the track while the truck bottom takes a bearing upon the press base, the wheels being released of all strain during the pressing operation. When the platen is returned, it again lifts the truck from the press base by raising the press track under the wheels and level with the track on the floor so that the truck can be run out of the press.

The strain rods are made of heat-treated forged steel and are machined to a diameter of 9 in. The heads of the strain rods are forged on. The heads take a bearing against split steel collars. The strain rod lugs on the cylinder and press base being bored, a perfect alignment is obtained through screwed strain rod collars.

Government Armor Plate Plant for West Virginia.—Secretary of the Navy Daniels recently announced that Charleston, W. Va., was the Government's choice as a site for its $11,000,000 armor plate and projectile plant.

An Automatic Pressure Regulator for Pulpwood Grinders

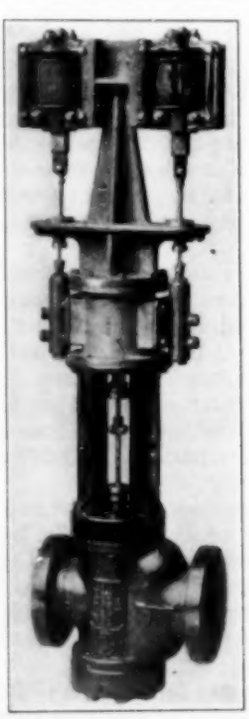
Mechanical wood pulp is made by grinding logs to fibre by means of a revolving grindstone. The logs are placed in cylinders, called pockets, and are forced against the stone by a hydraulic pressure.

During the process there is a constant variation of the total pressure on the stone, because the pressure will change when a pocket is opened to insert a new log and while the face of the new log is being ground down to fit the contour of the stone. This variation in pressure is objectionable for two reasons. It causes, in the first place, a variation in the quality and the quantity of the product, and, secondly, a variation in the power required to drive the stone. This second objection is of special importance when motor drive with central station current is used, because it causes numerous peak loads considerably above the average load and the rates for current are generally based on the maximum, and not the average, demand. Since a pulp wood grinder requires a good deal of power, the difference between the power paid for and that actually used for useful work may represent a considerable sum.

In order to insure a uniform pulp, increase the production and permit the grinder motor to operate at a load factor of practically 100 per cent, the Westinghouse Electric & Mfg. Co. has devised the regulator, shown in the illustration, which automatically varies the hydraulic pressure on the logs so that the load on the motor remains constant.

The action of the regulator is controlled by two solenoid magnets, which control the admission of the hydraulic pressure to the grinder cylinders containing the logs. When one of the solenoids is energized, pressure is admitted behind the pistons in the cylinders, thus increasing the pressure of the logs on the stone; when the other solenoid is energized, the pressure is admitted in front of the pistons, thus decreasing the pressure; when neither solenoid is energized the hydraulic valves are closed and the existing pressure is held.

The solenoids themselves are controlled by a set of relays, which receive current from a series transformer in the main motor circuit. The relays have two sets of contacts, each of which energizes one of the solenoids in the regulator. When the current taken by the motor exceeds a predetermined amount, one set of relay contacts is closed and as a result the pressure on the grindstone is decreased; while a decrease of current in the motor circuit increases the pressure on the stone. With normal current there is no variation in the pressure.



GENERAL VIEW OF PRESSURE REGULATOR

The results obtained by using this regulator are very marked. The power consumed by the grinder remains practically uniform at all times; a decided increase in production takes place; and the amount of shives, splinters and short fibers produced is reduced.

The regulator can be installed without alterations in the construction of the grinder and without interfering with

production. It it designed to be foolproof and its adjustments cannot be changed by the grinder operators. Whenever necessary it can be cut out of service.

An Interesting Application of Portable Elevators

The installation of an overhead motor is not an easy task by the ordinary method with scaffolding, special heavy platforms, blocks and falls, etc. It is worthy of note that this and similar lines of work, such as fixing pulleys, installing shafting, etc., can be done by portable elevators which were designed primarily for piling barrels, boxes, etc. It is claimed by a manufacturer of these revolving portable elevators that from four to six motors can be installed in this manner in the time formerly required for one.

In the accompanying illustration is shown a portable elevator called the "revolvator," made by the N. Y. Revolving Portable Elevator Co., Jersey City, N. J.

It consists essentially of two uprights or elevator guides, an elevating platform and a revolving base which can swing around on its ball-bearing center like a turntable. The unit is mounted on strong truck wheels and is equipped with a floor lock. A motor or other

MOTOR RAISED IN PLACE BY ELEVATOR

article to be raised is placed on the revolvator platform when down and by means of a crank and gears the platform is raised to the level desired. In elevating, the load is sustained independently of the crank, for a ratchet is provided with a special patented pawl which sustains the load at every point, eliminating all possibility of the platform being accidentally dropped.

Two sets of gears are provided, one for high speed and one for low. Loads up to 800 pounds can be raised on the high gear and heavier loads by the low gear. The machines are built from 6 to 20 feet in height. All machines 7 feet and larger have the frame hinged so that the top section may be folded over for the machine to pass through doorways. Special machines are built for lifting loads up to 2500 pounds, the standard revolvator being built in two sizes, one for loads up to 800 pounds and the other for loads up to 1800 pounds.

An Instrument for Indicating Jig Performance

A simple, but effective little instrument for indicating the performance of a jig has been designed and patented by W. F. Elwood, of Greensburg, Pa. The instrument consists simply of a cylinder, with a plunger having a needle on same, the needle moving on a scale as shown in Fig. 1. In Fig. 2, the jigometer is shown bolted to the screen of a coal jig, for which purpose it has been mainly used, although it would seem possible to apply it to jigs working on ores.

FIG. 1—GENERAL VIEW OF JIGOMETER

With every stroke of the jig plunger *F*, the needle *M* of the jigometer moves up and down accordingly.

Accumulation of refuse in the reservoir *K*, clogging of the gate at *C*, retarded pulsation of the plunger *F*, lack of water feed through *I* or lack of coal feed from *L* are all indicated by the position and performance of the needle *M* and can be immediately relieved. The jigometer is standardized for each particular jig on which it is intended to operate.

It is not necessary for the washerman to run his arm down into the dirty, black water in order to judge what is going on within the jig, but a glance at the needle of the jigometer tells him everything he needs to know in order to produce results.

It is claimed that this instrument solves the most perplexing phase of coal washing in that it positively registers the maximum and minimum bed required for the highest efficiency of the jigs; the maximum amount of refuse that may be permitted to collect in the reservoir

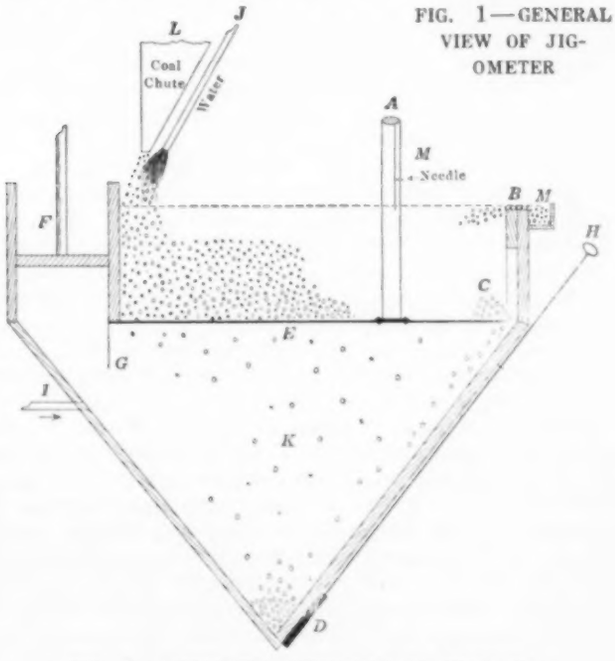


FIG. 2—JIGOMETER ATTACHED TO COAL JIG

below the screen before flushing the jigs, the depth to which the jigs should be flushed; the position of the water, the clearing ability of the screens and the efficiency of the jig plungers.

Metallurgical Fellowships at University of Utah

In the Department of Metallurgical Research of the State School of Mines, University of Utah, there have been established a number of research fellowships in metallurgy, having an annual value of $720. These fellowships are open to college graduates who have had a good training in chemistry and metallurgy, and applications for them will be received up to May 15, 1917. Applicants should send a copy of their records from the registrar's office of the college where they have been, or soon will be graduated, and the names and addresses of at least three references who know their character, ability and attainments to Joseph F. Merrill, Director Utah State School of Mines, Salt Lake City.

By an agreement with the United States Bureau of Mines, the work of the metallurgical research department is under the direction of metallurgists of the Bureau, assigned to duty at the University. Mr. A. E. Wells, metallurgist, is in charge of the work, assisted by other members of the metallurgical staff as follows: Mr. O. C. Ralston, metallurgist, Mr. J. C. Morgan, chemist, Dr. F. B. Laney, microscopist, and Mr. R. E. Head, metallurgical assistant.

Due to the fact that Salt Lake City and vicinity is one of the chief non-ferrous metallurgical centers of the United States, and that the work taken up is of practical nature, that is, has to do with the solution of definite practical problems, the University believes that these fellowships offer a splendid opportunity to young men intending to enter the metallurgical profession, to thoroughly familiarize themselves with up-to-date metallurgical practice, especially in the treatment of non-ferrous ores, and to become proficient in the adaptation of those processes which may be in line with the investigation carried on by them in connection with their work.

During the fiscal year 1916-1917 the following problems have engaged those holding fellowships:

A study of flotation processes in order to determine their applicability to the treatment of ores which are not at present treated by such processes, and especially the low grade oxidized ores of lead and of zinc.

A comparison of various flotation oils and the testing and preparation of new and more effective oils.

The hydrometallurgical treatment of low grade and complex ores of lead.

The use of salt in the igneous concentration of low grade lead ores from desert localities.

The removal of iron from complex sulphides of zinc and iron.

The preparation of pure solutions from oxidized ores of zinc.

The chemical precipitation of solutions of zinc.

Destructive distillation of some of the hydrocarbons of Utah, such as gilsonite, elaterite, tabbyite, etc.

Holders of these fellowships will be subject to the rules governing employees of the United States Bureau of Mines and will report for duty for twelve months beginning July 1, 1917. They must also register as students in the University of Utah and become candidates for the degree of Master of Science in Metallurgy (unless this or an equivalent degree has been previously earned). Their class work will be directed by the heads of the departments of instruction, but the greater portion of their time will be spent in laboratory work, directed by metallurgists of the Bureau of Mines.

Accurate Determination of the Critical Point During Annealing

It is a well known fact that steels begin to lose their magnetism when heated to the lower transformation point and that they are non-magnetic when the transformation range has been passed. Hence they lose their magnetism over a range of temperature, varying from nothing to over 100 deg. Fahr., depending on the amount of carbon in the steel and upon the other constituents.

It is also well established that it is undesirable in hardening to heat much above the highest transformation point, Ac_3, Ac_2 or Ac_1 as the case may be. The use of a horseshoe magnet was recommended in some of the older books as a valuable aid in determining the proper temperature. This necessitated taking the piece from the furnace, however or resulted in careless work and such a method is not practical where any amount of work is done.

It has recently been more and more recognized that the old well known property of loss of magnetism should be valuable in determining the critical point and thus in controlling hardening of steels, both as a method to be used alone and also in conjunction with pyrometers. For all ordinary purposes, steels with 0.35 carbon and upwards will be heated sufficiently high when they become non-magnetic. For steels with less carbon than this, which lose their magnetism at Ac_3 it is easy to judge by the eye when they are heated to the Ac_3 point.

A very practical and inexpensive device has recently been developed and placed on the market for utilizing the magnetic property of steels by the Slocum, Avram and Slocum Laboratories, 531 W. Twenty-first Street, New York. It consists of a specially designed magnet, condensed in size, properly suspended upon a brass arm, and carefully balanced to allow of considerable sensitiveness. The brass arm on which the magnet is balanced has interchangeable extensions, enabling the operator to apply the tool quickly and readily to furnaces of the smallest or largest type, or to an open forge. The simplicity of the apparatus and its freedom from anything which can get out of order would make it seem valuable for medium sized and smaller shops where extensive pyrometer installations and metallographic apparatus are not used, and also as a valuable accessory apparatus in any hardening plant, as pyrometers are not infallible and the magnet does away with the necessity of repeated laboratory tests to find the proper hardening temperature.

Personal

Mr. **Edward M. Brown,** one of the superintendents of the A. M. Byers Company, Columbia, Pa., has resigned, to take a position with Edward T. Edwards as assistant manager of the East End and Union Street rolling mills, operated in Columbia by Mr. Edwards. Mr. Brown has been connected with Columbia iron mills for twelve years.

Dr. **John C. Hebden,** vice-president and general manager of the Federal Dyestuff and Chemical Company, of Kingsport, Tenn., delivered an address before the Providence (R. I.) Engineering Society on Friday, April 20, on "Recent Advances in the Dyestuff Industry."

Messrs. **C. W. Hunt,** metallurgist and chemist; W. H. Goetz, mining and civil engineer, and L. F. Wolfinger, electrical and mechanical engineer, announce the opening of their offices at 803 Baker-Detwiler Building, Los Angeles, under the name of The Consolidated Engineers.

Mr. **Francis S. Schimerka,** who for the last four years has been in charge of leaching operations at the

Shannon Copper Company, Clifton, Arizona, has resigned his position.

Mr. **J. Arthur Singmaster** of the New Jersey Zinc Company, Palmerton, Pa., has been appointed general technical manager of the company, and will be located at the New York office of the company.

Mr. **A. M. Snyder,** mining engineer, metallurgist and specialist in flotation mills, has reopened his offices at 218-219 Security Building, Los Angeles.

Mr. **C. E. Thies** has severed his connection with Eimer & Amend and is now with the Palo Co., 90 Maiden Lane, New York City.

Mr. **G. P. Uppington** has been appointed district manager of the recently opened New York office at 90 West Street, of the Braemer Air Conditioning Corporation, of Philadelphia, Pa.

Mr. **Bruce I. Whiting,** formerly connected with the Snyder Electric Furnace Company, of Chicago, is now with C. W. Leavitt & Co., 30 Church Street, New York, in charge of sales of the Girod electric furnace, for which this company is the American agent.

Mr. **R. T. Will** has resigned his position as general superintendent and chemical engineer of the General Coal Products Company, of Pittsburgh, Pa., to establish offices and laboratories at Rochester, N. Y., for general testing and consultation in industrial and chemical engineering, under the name of The Will Corporation. The new laboratories are located at 262 East Avenue.

Book Reviews

Radio-Activity. By **F. C. Venable.** Handy size, 50 pages, $0.50. New York: D. C. Heath & Co.

A fascinating, finely written little book that can be read through in an hour. It gives the net results and conclusions of the last twenty years' study of radioactivity, the structure of the atom, and the constitution of matter.

* * *

Microscopic Examination of Steel. By **Henry Fay,** Ph.D., D.Sc. Octavo (15 x 22 cm.), 18 pages, 56 photomicrographs. Price, $1.25. New York: John Wiley & Sons, Inc.

A reprint of material originally published by the U. S. Ordnance Department, representing the results of investigations at the Watertown Arsenal. The text is very brief and to the point, and the photographs are very good. It is a mere outline of metallographic methods illustrated by typical examples, and is intended particularly to help learners or workers in metallography who need some precise advice and instruction in the interpretation of results. It is admirably suited to serve this end, within the limits imposed.

We heartily commend and agree with the author's comment that "there is a tendency to over-rate the application of metallography. Used in connection with the physical tests and chemical analyses it furnishes valuable supplementary data."

* * *

Awakening of Business. By **Edward N. Hurley,** Chairman of the Federal Trade Commission. Duodecimo (12 x 19 cm.), 240 pages. Price, $2.00 net. New York: Doubleday, Page & Co.

The distinguished economist here expresses in plain language the plain truths which he thinks American business men need to know and observe. It is intended not as a message of congratulation, but as one of warning. Its further intention is to inform them of Government activities in their behalf and bring them into closer harmony with the Government.

Parts of the book are elementary to the verge of inaninity. It is difficult to imagine that any man actually in business needs to be told the necessity for intelligent cost accounting, that "profit is the difference between cost and selling price," that depreciation must be properly allowed for, and a sinking fund provided for accidents or obsolescence of machinery. Such advice sounds like telling an engineer that he must not strain the material in a machine past its elastic limit, that he needs to apply a factor of safety to a construction; it seems like waste of ink and paper.

Other parts of the book, which utilize the special qualifications of the author to discuss the relations of Government to business, are valuable and illuminating. His discussions of Government regulation, trade associations, commercial education, foreign trade, and investment abroad are timely and thought-compelling, even though they may not always be completely convincing.

CURRENT MARKET REPORTS

The Iron and Steel Market

Consumers of steel products have continued to place contracts freely, despite the fact that delivery promises have become still more uncertain. There has been little buying of steel products for specific jobs, the great bulk of the business placed being in the form of ordinary contracts, which merely give the buyer a place on order books, orders to be filled in rotation. A very large business has been done in sheets and tin plates, the mills having opened books for the second half of the year early in April, and the total steel business done in the month will easily exceed the March total. The Steel Corporation's unfilled obligations, which increased by 134,947 tons in March, may show an increase of more than 500,000 tons for April.

In the last analysis, however, the steel business done is no accurate criterion of the steel trade's prospects, say for the next twelvemonth. There is reason to surmise that buyers of steel have acted upon their appraisal of prospects for steel supplies in future, rather than upon an appraisal of what their respective lines of activity will really require. The steel mills, as a rule, are filled with orders which cannot be completed in an average of less than 10 or 12 months. If the buyers of steel know for a certainty what quantities of their manufactured goods the public will be buying from them nine months hence they are certainly very wise. On the other hand it has required no great degree of courage to act upon the common belief that as war requires steel the material is going to be scarce for the duration of the war.

PRODUCTION HEAVIER

Transportation conditions as regards the iron and steel industry have improved further. Car supplies in the Connellsville coke region have become practically adequate and the blast furnaces are producing pig iron substantially at capacity, at a rate doubtless exceeding 40,000,000 tons a year. The steel mills are operating full and are shipping their entire product, while they have cleaned up practically all the accumulations of the winter. Some fears are entertained that with the opening of the season of lake navigation, with a heavy movement of coal to Lake Erie ports and a still heavier movement of ore therefrom a fresh congestion will be developed, but on the other hand there will soon be available the corrective influence of unit operation of the entire railway system of the country under the auspices of the Council of National Defense.

STEEL FOR WAR

For the 1917 naval program a trifle over 400,000 tons of steel has been secured by the Government, at 2.90c.

for the plates and 2.50c. for the relatively small tonnage of bars and plain shapes, these being the prices that ruled for several months prior to the advance of Aug. 1, 1916. About 75,000 tons of fitted structural work, for navy yard extensions, is included at a commensurate price. The "saving" to the Government is variously estimated at $10,000,000 to $18,000,000, depending upon whether comparison is made with premium prices now ruling for prompt deliveries, or with prices ruling for "delivery at mill convenience." It appears that the United States Steel Corporation, which makes about one-half the country's production, underwrote the whole business, while independent producers are now privileged to step up and undertake their respective shares.

Considerable tonnages of steel are involved in orders now being placed or about to be placed, for various camp paraphernalia, tent pins, tent stoves, camp ranges, barracks, etc. Orders for cables and wire rods for submarine defense have doubtless run into thousands of tons. Some of these orders preceded the declaration of war.

Until the item of shells is reached, the government's steel requirements can hardly total over a million tons for a twelvemonth. In shells, however, there is hardly any limit. When the matter is reached the Government will probably buy steel, in large rolled rounds and forging billets, and farm the steel out to shell manufacturers. The Government will probably itself buy the steel the European Allies may require. Price concessions on all this steel are expected.

The French Government has placed two rail orders, for 20,000 tons each, while Italy has bought 15,000 tons. A press dispatch from Petrograd is to the effect that Russia is about to buy 40,000 freight cars and 2000 locomotives, for delivery in July, 1918.

In the past few months the European Allies have greatly decreased their demands upon the United States for steel, having increased their own productive capacity, and very large business would have to be done, under the proposed plan of financing by the Government, to bring the flow of steel to the Allies up to the former rate. On account of the scarcity of bottoms exports of steel to neutral countries will undoubtedly be materially less than they were last year. All things considered, it does not seem probable that the supply of steel for ordinary domestic consumption will be greatly reduced. It cannot be regarded as probable, but it is conceivable, that if the war lasts another twelvemonth steel will be more plentiful then than now.

SCARCITY OF PIG IRON

There has been a wild scramble for pig iron in some districts, whereby the furnaces have become largely sold up for the first half of 1918, while furnaces in other districts still have tonnage available for the second half of this year. In all districts prompt iron is scarce, and prices have been advancing, though scarcely at as great a rate in the second half of April as in the first half. Prices at Birmingham range from $35 to $37. In the valley market Bessemer is $42 and basic, foundry and malleable $40, with occasional premiums for prompt shipment. The scarcity of pig iron represents the working out of a theory long entertained, that as steel making capacity has been increasing much more rapidly than blast furnace capacity the supply of pig iron would eventually prove inadequate. Steel billets, however, manage to maintain at least their former spread above pig iron, being $75 to $80 and hard to buy at that. Rods are commanding $85 to $90.

Finished steel prices are generally unchanged in the fortnight, except for advances in sheets, wire products and railroad spikes. Premiums for early deliveries, however, have increased. Early delivery plates have brought various prices from 6c. to 9c.

As noted in last report, the American Sheet & Tin Plate Company opened its books for second half deliveries at $7.50 for tin plate, 5c. for blue annealed sheets, 5.50c. for black sheets and 7c. for galvanized sheets, all in Bessemer, with a quarter-cent advance for open-hearth. Soon the company became sold up for the half-year and withdrew from the market. Independents then rapidly advanced their prices, the market being now quotable at 6c. to 6.75c. for blue annealed, 6.50c. to 7.50c. for black and 8c. to 9c. for galvanized. Independent tin plate mills closed with a few favored customers at $7.50, but in general have been booking their trade at $8, for Bessemer or open-hearth, while buyers not regular customers have paid $8.50.

Wire prices have advanced $6 a ton to 3.45c. for plain wire, 4.15c. for galvanized wire, $3.50 for wire nails, 3.65c. for painted barb wire and 4.35c. for galvanized barb wire.

Bars, plates and shapes are unchanged for delivery at mill convenience at 4.50c. for plates, 3.60c. for shapes and 3.35c. for bars, but in plates and shapes these prices are largely nominal.

The Non-Ferrous Metal Market

Monday, April 23.—No spectacular changes have occurred in the non-ferrous metal market during the past two weeks. Copper has declined slightly but no great weakness has developed. Tin is strong and has advanced. Lead is likewise strong and remains scarce. Spelter continues weak. Antimony has declined slightly while silver has advanced steadily.

Copper.—The situation in copper is very interesting. There have been no large offers by the large producers which would tend to depress the market, but resale lots by dealers coupled with a waiting policy on the part of consumers have lowered the market. Electrolytic has declined from 33.00 cents on the 12th to 31.50 on the 20th. Lake has declined from 33.50 on the 12th to 32.00 on the 20th. Brass exports in February continued very heavy, totaling in value over $30,000,000, which is nearly three times the value for the same period last year.

Tin.—The chief topic of interest centered in the import duty of 10 cents, which it was rumored would be placed on tin. In view of the fact that tin enters so largely into the making of cans and other tin plate articles, it is unlikely that the Government will take any action in this respect at this time. The consuming demand has not increased to any extent, and this probably accounts for the small advance in face of the small arrivals of 1800 tons up to the 19th and the advance in the London market. Spot Straits is quoted at 55.75 at present, with Banca tin offered at about 1 cent under this price.

Spelter.—This market is experiencing a very dull period. Prompt spelter has declined from 10.00 cents on the 12th to 9.30 on the 20th. Consumers seem to be holding off waiting action by the Government, whose business is expected to be in the intermediate and high grades. Ore prices are high and this reacts to the detriment of the smelters.

Lead.—Supplies of lead continue scarce both on spot and futures, and independents asking prices are somewhat higher, being 9.75 cents for prompt shipment. The Trust price of lead remains at 9.00 cents.

Other Metals.—Antimony continues high in price, but has declined from 35.50 to 34.00 cents. Aluminium is unchanged at 60.00 cents. Magnesium has dropped to $2.50 to $3.00 with a larger production. Quicksilver

is quoted at $113.00 per flask. Cadmium is $1.50, cobalt $1.70. Pure platinum is $105.00 per ounce. Silver is 74⅞.

Chemical Market

Coal Tar Products.—The general tendency of items under this classification has been to a decidedly firmer basis throughout the past two weeks and there has been very important buying on the part of consumers, who are seemingly of the opinion that the markets are to go against them. Producers have the situation well in hand, and it is rumored that a general understanding has been reached by the most important factors in regard to future operations. It is understood that this will mean higher prices for all crudes which have been advancing slowly but surely the past month, and especially an improved condition in the market governing phenol, which has been the only weak spot in the coal tar situation the past quarter. All coal tar crudes are considered good "buys" at the present moment.

Benzol.—Spot supplies have been practically eliminated from the market, and for future deliveries sellers are not inclined to offer any appreciable quantities except for nearby deliveries to regular consuming trade. A new buyer finds difficulty in securing quotations.

Toluol.—The situation is a very firm one indeed. The Government has already purchased 2,500,000 lb. of T. N. T., unrefined, and opens bids April 24th for 1,030,000 lb. refined and 700,000 lb. unrefined. The first purchase required approximately 100,000 gallons of toluol. These purchases are forerunners of regular requirements that are expected at comparatively short intervals from the government and can but reflect a firm situation in toluol. Excess profits will, of course, not be made on government business, but these supplies eliminated from the market will naturally result in a shortage of offerings for general industrial purposes.

Phenol.—Business continued disappointing and the anticipated demand for picric acid manufacture has not materialized. Apparently T. N. T. has supplanted picric acid as a popular explosive. However, in view of certain events the general opinion is that phenol will reach 50c. before the Fourth of July.

Aniline Oil.—Important business has passed for all nearby positions and prices are high and stocks extremely light. Some of the manufacturers who dropped out of the producing end some time ago as a result of low prices have again placed their plants in operation, but this increased output has not been as yet sufficiently large to take care of the greatly increased demand. The outlook for aniline oil appears quite bright after a depressing half-year.

Monochlorbenzol.—Manufacturers have caught up on their orders somewhat and contracts are now being made and offered at lower prices than have heretofore prevailed.

Beta Naphthol.—An important consuming demand has been noted from various technical sources and the position is somewhat improved, but poor quality offerings have had a tendency to keep price levels from advancing materially.

Benzidine.—There has been manufacturing difficulty reported, but the few producers are now selling about all the material they can offer.

Toluidines.—Practically all available capacity for producing *para* has been sold and manufacturers have been enabled to sell *ortho* at a low price because of the high price obtained for *para*. *Nitro toluols* have also been in urgent request. A producing source for *meta nitro para toluol* is reported, with the seller quoting $7.50.

Schaeffer Salt and *Brönner's Acid* are now being offered from a domestic manufacturing source, with prices quoted on the approximate basis of $2.00 to $2.25. It is also announced that supplies of *R acid* and *N* and *W acid* will shortly be available. The latter will probably be quoted in the neighborhood of $5.00.

H acid (the amidonaphthol disulphonic acid 1:8:3:6). —The situation has not changed much since our last report on this interesting product except that one of the producers has gone into receivership. Aside from the dye manufacturers who make for their own use there is only one firm making regular deliveries. A large number of companies plan a production, none of which has so far materialized.

Heavy Chemicals.—Practically every item in this classification has been subject to important consuming inquiry, and where prices have shown a tendency to advance consumers have generally rushed to cover. Exceptions have been cyanides and bichromates which have eased off. *Nitrate of soda* has been subject to a spectacular advance. Prices have more than doubled the past month. The two domestic producers are sold out and Norwegian importations have ceased. At least three new domestic manufacturing factors will enter the market within the year. *Caustic soda* and *soda ash* have been very active and short interests have been covering. Nineteen-seventeen business is difficult to obtain and most producers are sold out for the best part of 1918. Three-year contracts are being turned down. Ordinarily a producer will take business for several years ahead. Indications point to continued firmness. *Bichromates* markets, subject nearly always to considerable manipulation, have gradually declined and business has been taken for export at the lowest figure that has prevailed for some little time. *Cyanides* are moving slowly and the position has been much easier as a result of the large offerings of Japanese material. *Chlorates* have also been rather neglected after an active year. The general market appears to be gradually adjusting itself to war time business and interesting developments are looked for.

General Chemicals

WHOLESALE PRICES IN NEW YORK MARKET APRIL 21, 1917

Acetic anhydride	lb.	1.50 —	1.75
Acetone Drums	lb.	.27 —	.27½
Acid, acetic, 28 per cent	lb.	.04½ —	.05
Acetic, 56 per cent	lb.	.09 —	.10
Acetic, glacial, 99½ per cent carboys	lb.	.28 —	.30
Boric, crystals	lb.	.10½ —	.11
Citric, crystals	lb.	.73 —	.75
Hydrochloric, commercial, 18 deg	lb.	.01¼ —	.01⅜
Hydrochloric, 20 deg	lb.	.01⅜ —	.01⅝
Hydrochloric, C. P., conc., 22 deg	lb.	.01⅝ —	.01¾
Hydrofluoric, 30 per cent. in barrels	lb.	.04¾ —	.05
Lactic, 44 per cent	lb.	.11 —	.12
Lactic, 22 per cent	lb.	.04½ —	.05
Nitric, 36 deg	lb.	.05¼ —	.05½
Nitric, 42 deg	lb.	.06½ —	.07
Oxalic, crystals	lb.	.45½ —	.46
Phosphoric, 85 per cent	lb.	.33 —	.37
Picric	lb.	.70 —	.75
Pyrogallic, resublimed	lb.	3.50 —	4.00
Sulphuric, 60 deg	ton	19.00 —	20.00
Sulphuric, 66 deg	ton	29.00 —	30.00
Sulphuric, oleum (Fuming), tank cars	ton	38.00 —	40.00
Tannic, U. S. P. bulk	lb.	.45 —	.50
Tartaric, crystals	lb.	.83 —	.85
Alcohol, grain, 188 proof	gal.	3.03 —	3.05
Alcohol, wood,, 95 per cent	gal.	1.00 —	1.02
Alcohol, denatured, 180 proof	gal.	.70 —	.72
Alum, ammonia lump	lb.	.04 —	.04½
Alum, chrome ammonium	lb.	.17½ —	.20
Alum, chrome potassium	lb.	.35 —	...
Alum, chrome sodium	lb.	.12 —	.12½
Alum, potash lump	lb.	.05½ —	.05¾
Aluminium Sulphate, technical	lb.	.01¾ —	.02
Aluminium Sulphate, iron free	lb.	.03 —	.03¼
Ammonia aqua, 26 deg. carboys	lb	.05¾ —	.06
Ammonium carbonate	lb.	.12 —	.13
Ammonium nitrate	lb.	.16 —	.17
Ammonium, sulphate domestic	lb	.05½ —	.06
Amyl acetate	gal.	4.00 —	4.25
Arsenic, white	lb.	.14 —	.17
Arsenic, red	lb.	.30 —	.60
Barium chloride	ton	85.00 —	90.00
Barium sulphate (Blanc Fixe) powder	lb.	.04 —	.04½
Barium nitrate	lb.	.10½ —	.11
Barium peroxide basis 70 per cent	lb.	.27 —	.27½
Bleaching powder, 35 per cent chlorine	lb.	.03½ —	.03¾
Borax, crystals, sacks	lb.	.07½ —	.08
Brimstone, crude	ton	45.00 —	...
Bromine, technical	lb.	.80 —	.90
Calcium, acetate, crude	lb.	.03 —	.03½

Calcium, carbide	ton	80.00 —	90.00
Calcium chloride, 70-75 per cent, fused, lump	ton	26.00 —	28.00
Calcium peroxide	lb.	1.80 —	1.90
Calcium phosphate	lb.	.30 —	.31
Calcium sulphate	lb.	.01 —	.02
Carbon bisulphide	lb.	.04 —	.04½
Carbon tetrachloride, drums	lb.	.15 —	.16
Caustic potash, 82-92 per cent	lb.	.76 —	.78
Caustic soda, 76 per cent	100 lb.	4.75 —	4.85
Chlorine, liquid	lb.	.15 —	.18
Cobalt oxide	lb.	... —	...
Copperas	100 lb.	1 05 —	1.10
Copper carbonate	lb.	.33 —	.35
Copper cyanide	lb.	.75 —	...
Copper sulphate, 99 per cent, large crystals	lb.	.09 —	.09½
Cream of tartar, crystals	lb.	.46½—	.47
Epsom salt, bags	100 lb.	3.25 —	3.50
Formaldehyde, 40 per cent	lb.	.14½—	.15
Glauber's salt	100 lb.	.62 —	.64
Glycerine, bulk, C. P.	lb.	.56 —	.57
Iodine, resublimed	lb.	3.50 —	...
Iron oxide	lb.	.02 —	.08
Lead acetate, white crystals	lb.	.14 —	.14½
Lead arsenate	lb.	.10 —	.11
Lead nitrate	lb.	.16½—	.17
Litharge, American	lb.	.08 —	.19
Lithium carbonate	lb.	1.02 —	1.05
Manganese dioxide	lb.	.65 —	.66
Magnesium carbonate tech.	lb.	.24 —	.26
Nickel, salt, single	lb.	.14 —	.14½
Nickel, salt, double	lb.	.11 —	.12
Phosphorous, red	lb.	1.15 —	1.25
Phosphorus, yellow	lb.	1.05 —	1.10
Potassium, bichromate	lb.	.34½—	.35
Potassium bromide granular	lb.	1.00 —	1.05
Potassium carbonate calcined, 80-85 per cent	lb.	.31 —	.35
Potassium chlorate, crystals	lb.	.58 —	.60
Potassium cyanide, 98-99 per cent	lb.	1.35 —	1.40
Potassium iodide	lb.	2.90 —	2.92
Potassium muriate, 80-85 p. c., basis of 80 p.c.	ton	390.00 —400.00	
Potassium nitrate	lb.	.30 —	.32
Potassium permanganate	lb.	3.65 —	3.75
Potassium prussiate, red	lb.	2.60 —	2.70
Potassium prussiate, yellow	lb.	.92 —	.94
Potassium sulphate, 90-95 p. c., basis 90 p. c.	ton	310.00 —325.00	
Rochelle salts	lb.	.37½—	.38½
Sal ammoniac, gray gran	lb.	.11 —	.12
Sal ammoniac, white gran	lb.	.17 —	.18
Sal soda	100 lb.	1.10 —	1.20
Salt cake	100 lb.	.90 —	1.00
Silver cyanide	oz.	.70 —	...
Silver nitrate	oz.	.46⅞—	...
Soda ash, 58 per cent, light, flat	100 lb.	3.25 —	3.30
Soda ash, 58 per cent, dense, flat	100 lb.	3.60 —	3.65
Sodium acetate	lb.	.08½—	.09
Sodium benzoate	lb.	7.00 —	7.25
Sodium bicarbonate, domestic	100 lb.	1.95 —	2.00
Sodium bicarbonate, English	lb.	... —	...
Sodium bichromate	lb.	.14½—	.15
Sodium bisulphite, powd	lb.	.03½—	.04
Sodium chlorate	lb.	.23½—	.25
Sodium cyanide	lb.	.90 —	1.05
Sodium fluoride, commercial	lb.	.11⅜—	.12
Sodium hyposulphite	lb.	.01⅜—	.02
Sodium nitrate, refined	lb.	.05½—	.05¾
Sodium nitrite	lb.	.29 —	.31
Sodium peroxide	lb.	.90 —	.95
Sodium phosphate (tri)	lb.	.04½—	.04¾
Sodium prussiate, yellow	lb.	.30 —	.31
Sodium silicate, liquid—40 deg. Baume	100 lb.	1.20 —	1.30
Sodium sulphide, 30 per cent. crystals	lb.	.03 —	.03¼
Sodium sulphide, 60 per cent. fused	lb.	... —	...
Sodium sulphite	lb.	.03¼—	.03½
Strontium nitrate	lb.	.28 —	.30
Sulphur chloride, drums	lb.	.11 —	.12
Sulphur, dioxide, liquid, in cylinders	lb.	.11½—	.12
Sulphur, flowers, sublimed	100 lb.	3.20 —	3.30
Sulphur, roll	100 lb.	2.55 —	2.60
Sulphur, crude	ton	45.00 —	46.00
Tin bichloride, 50 deg.	lb.	.14¼—	.14½
Tin oxide	lb.	.54 —	.56
Tungstic acid, basis 100 per cent.	lb.	1.40 —	1.50
Zinc carbonate	lb.	.26 —	.27
Zinc chloride	lb.	.15 —	.15½
Zinc cyanide	lb.	.50 —	...
Zinc dust, 350 mesh	lb.	.19 —	.20
Zinc oxide, American process, XX	lb.	.12 —	.12½
Zinc sulphate	lb.	.06½—	.07

Coal Tar Products (Crude)

Benzol, pure, water white	gal.	.58 —	.60
Benzol, 90 per cent.	gal.	.57 —	.59
Toluol, pure, water white	gal.	1.90 —	2.00
Xylol, pure, water white	gal.	.60 —	1.00
Solvent naphtha, water white	gal.	.17 —	.20
Solvent naphtha, crude, heavy	gal.	.13 —	.16
Creosote oil, 25 per cent.	gal.	.28 —	.30
Dip oil, 20 per cent.	gal.	.24 —	.26
Pitch, various grades	ton	8.00 —	20.00
Carbolic acid, crude, 95-97 per cent.	lb.	.90 —	.95
Carbolic acid, crude, 50 per cent.	lb.	.55 —	.60
Carbolic acid, crude, 25 per cent.	lb.	.30 —	.32
Cresol, U. S. P.	lb.	.20 —	...

Intermediates, Etc.

Alpha naphthylamine	lb.	.90 —	1.05
Aniline oil	lb.	.28½—	.30
Aniline salts	lb.	.32 —	.34
Anthracene, 80 per cent.	lb.	.10 —	...
Benzaldehyde	lb.	4.50 —	5.00
Benzidine, base	lb.	1.85 —	2.00
Benzidine, sulphate	lb.	1.60 —	1.65
Benzoic acid	lb.	7.00 —	7.50
Beta Naphthol, sublimed	lb.	.80 —	.85
Dichlor benzol	lb.	.23 —	.24
Dinitro chlorbenzol	lb.	.46 —	.48
Dimethylaniline	lb.	.57 —	.59
Diphenylamine	lb.	.85 —	.90
H-Acid	lb.	Nominal	
Metaphenylenediamine	lb.	1.60 —	1.65
Monochlorbenzol	lb.	.30 —	.32
Naphthalene, flake	lb.	.09½—	.10
Naphthionic acid, crude	lb.	1.50 —	1.75
Nitro naphthalin	lb.	.50 —	.60
Ortho-amidophenol	lb.	... —	...
Ortho-toluidine	lb.	1.20 —	1.30
Para-amidophenol base	lb.	5.00 —	5.50
Paranitraniline	lb.	1.20 —	1.25
Paraphenylenediamine	lb.	3.50 —	3.75
Para toluidine	lb.	2.25 —	2.50
Phenol, U. S. P.	lb.	.42 —	.44
Resorcin, technical	lb.	9.00 —	...
Resorcin, pure	lb.	16.00 —	17.00
Salicylic acid	lb.	.83 —	.85
Salol	lb.	1.40 —	1.60
Sulphanilic acid	lb.	.32 —	.33
Tolidin	lb.	3.00 —	...
Toluidine-mixture	lb.	.65 —	.80

Petroleum Oils

Crude (at the Wells)

Pennsylvania	bbl.	3.05 —	...
Corning, Ohio	bbl.	2.38 —	...
Somerset, Ky.	bbl.	2.18 —	...
Wooster, Ohio	bbl.	2.05 —	...
Indiana	bbl.	1.73 —	...
Illinois	bbl.	1.87 —	...
Oklahoma and Kansas	bbl.	1.70 —	...
Caddo, La., light	bbl.	1.90 —	...
Corsicanna, Tex., light	bbl.	1.70 —	...
California	bbl.	.73 —	.82

Lubricants

Black, reduced, 29 gravity, 25-30 cold test	gal.	.13½—	.14
Cylinder, light	gal.	.21 —	.26
Cylinder, dark	gal.	.18 —	.19
Paraffine, high viscosity	gal.	.29½—	.30
Paraffine, .903 sp. gr.	gal.	.21½—	.22
Paraffine, .865 sp. gr.	gal.	.18½—	.19

Flotation Oils

(Prices at New York)

Pine oil, steam distilled, sp. gr. 0.925-0.940	gal.	.52½—	...
Pine oil, destructively distilled, sp. gr. 0.920-0.940	gal.	.48 —	...
Pine-tar oil, sp. gr. 1.025-1.035	gal.	.23 —	...
Pine-tar oil, double refined, sp. gr. 0.965-0.990	gal.	.32 —	...
Pine oil, light, sp. gr. 0.950, tank cars	gal.	.37 —	...
Pine oil, heavy, sp. gr. 1.025, tank cars	gal.	.26 —	...
Pine tar, thin, sp. gr. 1.060-1.080	gal.	.40 —	...
Turpentine, crude, gr. 0.980-1.000	gal.	.19 —	...
Hardwood oil, sp. gr. 0.960-0.990	gal.	.21 —	...
Hardwood oil, sp. gr. 1.06-1.08	gal.	.23 —	...

Vegetable and Other Oils

China wood oil	lb.	.14½—	.15
Cottonseed oil, crude	gal.	1.00 —	...
Linseed oil, raw, cars	gal.	1.14 —	...
Peanut oil, crude	gal.	1.15 —	...
Rosin oil, first run	gal.	.38 —	...
Rosin oil, fourth run	gal.	.67 —	...
Soya bean oil, Manchuria	lb.	.13½—	...
Turpentine, spirits	gal.	.52 —	...

Miscellaneous Materials

Barytes, floated, white, foreign	ton	38.00 —	40.00
Barytes, floated, white, domestic	ton	28.00 —	32.00
Beeswax, white, pure	lb.	.52 —	...
Carnauba wax, highest grade	lb.	.51 —	...
Chalk, light, precipitated, English	lb.	.03 —	.06
Feldspar	ton	8.00 —	12.00
Fuller's earth, powdered	100 lb.	.80 —	1.05
Ozokerite, crude, brown	lb.	.60 —	.70
Ozokerite, American	lb.	.35 —	...
Red lead, dry, carloads	lb.	.10½—	...
Rosin, 280 lb.	bbl.	6.00 —	...
Soapstone	ton	10.00 —	12.50
Talc, American, white	ton	10.00 —	13.00
White lead, dry	lb.	.09⅝—	...

Refractories, Etc.

(F.O.B. Works)

Chrome brick	net ton	Nominal	
Chrome cement, Grecian	net ton	60.00 —	...
Clay brick 1st quality fireclay	per 1000	45.00 —	...
Clay brick, second quality	per 1000	30.00 —	...
Magnesite, Grecian, dead burned	net ton	90.00 —	...
Magnesia brick, Grecian, 9x4½x2½	net ton	140.00 —	...
Silica brick	per 1000	45.00 —	...

Ferroalloys

Ferrochromium	lb.	Nominal	
Ferromanganese, domestic, delivered	ton	400.00 —425.00	
Ferromanganese, English	ton	200.00 —	...
Ferromolybdenum, per lb. of Mo.	lb.	4.00 —	...
Ferrosilicon, 50 per cent, carloads, del. Pittsburgh	ton	200.00 —225.00	
Ferrosilicon, 50 per cent, contract	ton	100.00 —	...
Ferrotungsten, 75-85 per cent, f.o.b. Pittsburgh	lb.	2.00 —	...
Ferrovanadium, f.o.b. works	lb.	2.75 —	3.00

INDUSTRIAL

Financial, Construction and Manufacturers' News

Financial

New Companies

The Acme Dye and Chemical Co., Metuchen, N. J., has been incorporated with a capital of $100,000 to manufacture chemicals and oils.

The Alumetal Co., Wilmington, Del., has been incorporated with a capital of $600,000 to do a general mining, milling and refining business. The incorporators are H. R. Latter, N. P. Coffin, C. M. Egner, Wilmington, Del.

Anchor Sheet Glass Co., Del., has been incorporated with a capital of $2,000,000 to manufacture sheet glass products of all kinds. The incorporators are D. H. Feltner, A. A. Icanhour, C. W. Barnet, Clarksburg, W. Va.

The Arizona Superior Copper Company, Newark, N. J., has been incorporated with a capital of $5,000,000. The incorporators are George H. Russell, Frank H. Van Winckle and Nelson R. Vanderhoff. The local agent is the New Jersey Corporation Agency, of 243 Washington Street.

A. H. Y. Color Chemical Company, Bridgeton, N. J., has been incorporated with a Delaware charter and capital of $10,000 to operate a local plant. The incorporators are A. H. and B. R. Yudizky, Bridgeton, and William K. Harris, Woodbine, N. J.

Aryl Chemical Co., Brooklyn, N. Y., has been incorporated with a capital of $5,000 to manufacture synthetic organic compounds. The incorporators are Jacob Jay, Wilhelm Greenberg, Michael Greenberg.

F. Behrend, Inc., New York, has been incorporated with a capital of $100,000 to conduct a mining, chemical and timber business. The incorporators are J. H. Beckwith, W. and F. Behrend, 54 Front Street.

The Bernens Mining Co., Tacoma, Wash., has been incorporated with a capital of $500,000. The incorporators are H. H. Smith, Tacoma; A. Geo. Elmer, Seattle; Judge Thos. R. Lyons, Seattle; Jas. Closkey, Juneau, and Geo. E. Dailey, Tacoma.

Big Wizard Chemical Co., Cincinnati, Ohio, has been incorporated with a capital of $5,000. Incorporator Malcolm W. McIntyre.

Blumer Dye Co., Pensacola, Fla., has been incorporated with a capital of $10,000 to deal in dyes. The incorporators are Wm. Blumer, T. L. Grant, Geo. Earl Hoffman.

Bowman Mell & Co., Harrisburg, Pa., has been incorporated with a capital of $25,000 to deal in chemicals and drugs.

Brunswick Chemical Co., Newark, N. J., has been incorporated with a capital of $200,000 to manufacture chemicals, dyes and drugs. The incorporators are Augustus C. Studer, Jr., D. B. Smith, V. B. Havens, Newark.

Central Graphite Company, 402 Jefferson County Bank Bldg., Birmingham, Ala., has been incorporated with a capital of $300,000 to mine and refine graphite. The incorporators are Harry Watkins, Sr., H. O. Moore, E. N. Hamill.

Chase Gasoline Co., Sistersville, W. Va., has been incorporated with a capital of $50,000. The incorporators are Jos. McKay, J. J. McKay, R. Broadwater, W. G. Maxwell and others.

Chemung Refining Co., Cushing, Ohio, has been incorporated with a capital of $20,000. The incorporators are L. M. Ridelsperger, A. F. Levery, A. J. Lavery, Cushing.

Columbia Chemical Corporation, Roanoke, Va., has been incorporated with a capital of $500,000 to manufacture and deal in chemicals. The incorporators are H. B. Goodloe, S. W. Hairston.

The Continental Oil and Gas Co., Parkersburg, W. Va., has been incorporated with a capital of $150,000 to operate extensive natural gas and oil fields in that State. The incorporators are C. T. Hitesgew, W. M. Smith, H. O. Hitesgew and others.

Dixie Graphite Co., Llano, Tex., has been incorporated with a capital of $150,000 to mine and deal in graphite. The incorporators are W. McCarthy Moore, Will T. Moore and Euegen Moore.

Empire Gas and Fuel Co., Louisville, Ky., has been incorporated with a capital of $100,000. The incorporators are Rodman Grubbs, Jos. W. Fowler, Jr., Wm. A. Rosenfield and others.

Federal Steel Products Corp., New York, has been incorporated with a capital of $1,000,000 to manufacture steel and all its products.

Floatone Chemical Co., Inc., has been incorporated with a capital of $10,000 to deal in acids, alkalis, chemicals. The incorporators are F. T. Dugan, F. M. Vanwagonen, H. A. Flukiger, 27 Pine Street, New York.

Granite City Coke and Chemical Co., Portland, Me., has been incorporated with a capital of $100,000 to deal in coal, coke, oils, iron, steel, etc.

Gulf Fish Oil and Fertilizer Co., Galveston, Tex., has been incorporated with a capital of $50,000. The incorporators are J. W. Nunn, C. Biehl, P. Lobit and others.

Hercules Ore Corporation, New York, has been incorporated with a capital of $100,000 to mine for minerals of all kinds. The incorporators are S. B. Howard, A. W. Britton, H. B. Davis, all of Wilmington.

Hood-Graves Graphite Co., Ashland, Ala., has been incorporated with a capital of $100,000 to mine and deal in graphite. The incorporators are William Hood of Birmingham; W. D. Graves, Jacob A. Walker, A. P. Gross and others of Alexander City, Ala.

Howes Brothers and Hine Co., Portland, Me., has been incorporated with a capital of $2,500,000 for manufacturing, tanning, dealing in hides, leather, lumber, bark, machinery, etc.

Illinois Producing & Refining Co., Wilmington, Del., has been incorporated with a capital of $500,000 to acquire and develop lands containing oil, etc. Mr. F. D. Buck, Geo. W. Dillman, K. E. Longfield, all of Wilmington, incorporators.

International Mica Mineral Company, Dover, Del., has been incorporated with a capital of $200,000 to mine for mica and prepare the same for market. The incorporators are L. B. Phillips, J. B. Bailey, local Dover, Del., incorporators.

Intermountain Oil Co., Butte, Mont., has been incorporated with a capital of $500,000 to engage in all kinds of mining. The incorporators are L. H. Kelly, C. S. McCoy, Maxwell Petersot and D. H. Mottleson, all of Butte.

James Chemical Dye Works, Joplin, Mo., has been incorporated with a capital of $2,000 to deal in chemicals. The incorporators are H. T. James, Edward James and A. M. Bradley.

The James-Hazelip Oil and Refining Co., Wilmington, Del., has been incorporated with a capital of $1,000,000 to drill and bore for oil and natural gas. Incorporators are K. M. Dougherty, C. Fearon, E. Lynch, all of Wilmington.

Kanawha Oil Co., Bartlesville, Okla., has been incorporated with a capital of $200,000. The incorporators are H. Thompson, Clinton; A. E. Bell and A. J. Stratoon.

Kansas-Oklahoma-Texas Oil and Gas Development Co. has been incorporated with a capital of $5,000,000. The incorporators are J. H. Butts, Wichita; J. W. Hiatt, Winfield; T. C. Coffman, Wichita; H. W. Lewis, Wichita.

Kingston Paper Co., Inc., N. Y., has been incorporated with a capital of $30,000 to deal in paper, felt and similar products. The incorporators are H. Horwitz, P. Kingston, Little Falls, N. Y.

Liberty Oil and Gas Corp., Wilmington, Del., has been incorporated with a capital of $250,000.

Louisiana-Kentucky Fluorspar and Lead Co., Wilmington, Del., has been incorporated with a capital of $250,000 to mine for ores of all kinds.

Martin-Camp Co., Hornell, N. Y., has been incorporated with a capital of $100,000 to deal in coal, coke, wood, oil, gas, timber. The incorporators are I. L. Camp, F. R. Series, W. Martin.

The Massillon Smelter Co., Massillon, Ohio, has been incorporated with a capital of $10,000. Incorporators, William Dryant and others.

Midland Oil, Gas & Refining Co., Portland, Me., has been incorporated with a capital of $1,000,000 to manufacture, refine, operate oil wells, minerals, etc.

Monitor Graphite Co., Ashland, Ala., has been incorporated with a capital of $100,000. The incorporators are Wm. J. Andrews, Thomas M. Webb, both of Raleigh, N. C. The company will install a $40,000 plant.

Muskogee Glass Manufacturing Co., Muskogee, Okla., has been incorporated.

The National Steel Products Co., Mansfield, Ohio, has been incorporated with a capital of $25,000. The incorporators are C. Oberlin, R. W. Martin, Chas. A. Longsdorf, W. F. Black and D. F. Brucker.

New England Oil Paint and Varnish Co., Ridgewood, has been incorporated with a capital of $100,000 to manufacture chemicals and alkalis. The incorporators are B. Batnet, Paterson; J. H. McClellan, Boston; L. Coh, Ridgewood.

New Process Chemical Co., New York City, has been incorporated with a capital of $150,000 to manufacture paints, varnishes, etc. The incorporators are E. Willoughby, Middletown; Stafford Smith, Wm. F. Cahill.

North American Petroleum and Gas Co., Del., has been incorporated with a capital of $2,000,000 to mine for and market petroleum. The incorporators are F. R. Hansell, Philadelphia, Pa.; Geo. H. B. Martin, S. C. Seymour, Camden, N. J.

Onondaga Petroleum Corp., Tully, N. Y., has been incorporated with a capital of $750,000 to deal in oil, gas and mineral business of all kinds. The incorporators are F. P. Assmann, L. Vinhav, Syracuse; F. L. Smith, Dwight, Ill.

Overland Trading Corp., Hoboken, N. J., has been incorporated with a capital of $6,250 to manufacture and deal in dyestuffs, chemicals, etc. The incorporators are N. Marcus, R. E. Hetzel, H. J. Camby, Hoboken.

Charles L. Payne Chemicals and Specialties Co., Inc., New York, has been incorporated with a capital of $10,000 to deal in drugs, chemicals, toilet articles. The incorporators are R. F. Lewis, V. Du Bois, C. L. Payne, 31 Union Square.

Peerless Sal-o-well Co., Buffalo, has been incorporated with a capital of $50,000 to manufacture and deal in polishes, dyestuffs, soaps. The incorporators are L. S. Wilkie, G. S. Salsbury, G. W. Smith, 91 Charlotte Ave., Buffalo.

Portland Cement Co., Petoskey, Mich., has been incorporated with a capital of $1,000,000.

Prudential Oil Co. of Texas has been incorporated in Delaware with a capital of $1,000,000 to acquire oil lands, and to develop the same. The incorporators are W. F. O'Keefe, E. E. Wright, Geo. S. Steigler, all of Wilmington.

Robert Rauth, Inc., Newark, N. J., has been incorporated with a capital of $50,000 to manufacture and deal in rosin products, chemicals and brewers' supplies. The incorporators are Robert Sims, Newark; Emil Breitenfeld, S. Sholes, New York.

E. E. Reifenberg & Bro., Inc., has been incorporated with a capital of $3,000 to deal in chemicals, metals, ores, minerals. The incorporators are G. W. Heining, J. D. McQuade, E. E. Reifenberg, 53 West 94th Street, New York.

Roanoke Iron and Steel Corporation, Wilmington, Del., has been incorporated with a capital of $3,500,000 to manufacture iron, steel, etc. The incorporators are H. E. Latter, Norman P. Coffin, Clement M. Egner, local Wilmington incorporators.

Santo Domingo Development & Investment Corp., Portland, Me., has been incorporated with a capital of $100,000 to deal in oil wells, refineries.

Southern Smelting & Refining Co., Wilmington, Del., has been incorporated with a capital of $1,000,000 to do a general business of mining in all its branches.

Standard Silicon Co., Delaware, has been incorporated with a capital of $1,500,000 to manufacture silica and silica products. The incorporators are Andrew W. Urmann, Ridgeway, Pa.; Francis A. Guber, Geo. S. Supprecht, St. Mary's, Pa.

The Steel and Tool Exchange, Manhattan, has been incorporated with a capital of $10,000 to manufacture tungsten and high-speed steel. The incorporators are James Duffy, Fred Holman, John J. Reilly.

The Toledo Seed & Oil Co., Toledo, Ohio, has been incorporated with a capital of $300,000. Incorporator, Geo. A. Vradenburg.

Triangle Oil and Refining Co., Del., has been incorporated with a capital of $1,000,000 to refine, and deal in and with pe-

troleum and its products. The incorporators are Chas. B. Bishop, M. L. Gatchell, E. E. Bishop, Wilmington.

B. Ullman & Co., Inc., Manhattan, has been incorporated with a capital of $100,000 to manufacture and deal in liquid and powdered bronze, powders, metallic, leaves, etc. The incorporators are S. M. Kazarus, J. T. Abeles, W. P. Riley, 2 Rector Street, New York.

United Oil and Gas Co., Kokomo, Ind., has been incorporated with a capital of $200,000. The incorporators are J. Frank Lindsey, Addison Jenkins, H. D. Wilcutts.

The Utica Chemical Co., Inc., Utica, N. Y., has been incorporated with a capital of $200,000. The incorporators are A. M. Thomsen, Wm. S. Bacot and H. H. Thompkins.

Venezuelan Fields Limited, Wilmington, Del., has been incorporated with a capital of $1,000,000 to carry on the business of producing crude oil and its products. The incorporators are H. E. Latter, Norman P. Coffin, Clement M. Egner, local Wilmington, Del.

Washington-Wyoming Oil Co., Seattle, Wash., has been incorporated with a capital of $6,000,000. The incorporators are Geo. W. Dutton and M. O. Bluhm.

Wichita Asphalt Paint & Varnish Co., Wichita Falls, Tex., has been incorporated with a capital of $30,000. The incorporators are V. H. Williams, J. D. Miller and W. E. Griggs, all of Gainesville.

Wyoming-Platte Valley Oil Co., Torrington, Wyo., has been incorporator with a capital of $500,000. The incorporators are J. T. Snow, D. C. Nolan, C. G. Parker, L. A. Rott, J. M. Ingram, B. F. Smith and J. L. Sawyer.

Financial Reports, Capital Increases, Etc.

The E. I. du Pont de Nemours Company, through its subsidiary, the Dupont Chemical Works, is reported to have been negotiating for the purchase of the large dye plant of Marden, Orth and Hastings at Newark, N. J. The plant consists of twenty-one buildings devoted to the manufacture of intermediate and dyestuffs, and includes complete control and research laboratories.

The Grasselli Chemical Co. of Cleveland has asked for a receiver for the Aetna Explosives Co. The Grasselli Co. is creditor for $103,655, and it is understood that there are numerous other creditors. In spite of this fact it is stated that the Aetna company's assets are far in excess of its liabilities and that it would seriously embarrass the Government to have the properties sold, in view of the munition contracts for domestic and foreign shipment.

The Rollin Chemical Co., Inc., New York, has increased its capital from $1,600,000 to $2,000,000.

The capital stock of the Union Carbide Company has been increased from $30,000,000 to $50,000,000.

The Logwood Chip Co., Ltd., New York, has reduced its capital stock from $100,000 to $30,000.

The Standard Oil Co. of Indiana filed notice with the secretary of state of a meeting of stockholders, at which the capital stock was increased from $30,000,000 to $100,000,000.

Stevens Grease and Oil Company, Cleveland; increase from $150,000 to $250,000.

Federal Foundry Supply Company, Cleveland, $75,000 to $125,000.

Increase in capital of Continental Machine and Foundry Co., Chicago, Ill., from $400,000 to $500,000.

Application has been filed to increase the capital stock of the National Steel Company, Havana, Cuba, from $100,000 to $250,000.

Some of the stockholders of the Union Oil Company, outside the active officials of the corporation, it is reported, are agitating a plan to increase the capital stock of the corporation from $50,000,000 to $100,000,000, and to issue a stock dividend covering the present surplus of the company, which amounts to around $17,000,000. This would mean a stock dividend of about 50 per cent of the outstanding stock. In other words, every stockholder would get one additional share of treasury stock for each two shares he now owns.

The properties of the Union Oil Company are said to be worth $100,000,000 or more. Patented oil lands are increasing in value rapidly on account of scarcity, and also because of the efforts of the federal government to conserve the petroleum deposits, especially in lands for which the title has not passed from the government.

Construction and Operation

Alabama

ASHLAND.—The plant of the American Graphite Company near Ashland will be in operation very soon.

BIRMINGHAM.—The Hill-Griffith Company will construct a mill for grinding crude graphite and refining it, on Seventh Avenue near Thirtieth Street. Alabama has recently become a graphite mining state and the Hill-Griffith Company is planning to take advantage of the newly developed resources.

California

LOS ANGELES.—The American Solvay Process Company of Syracuse and the Pacific Coast Borax Company are jointly constructing a potash plant here in Trona on Searles Lake. It is expected to have the plant finished in about two months. It will cost when completed with tramways and equipment over $1,000,000. Extensive leases are held on Searles Lake deposits, which carry large quantities of borax, potash and soda.

Colorado

DENVER.—The Colorado Power Company has signed a contract for an electrometallurgical installation for a manufacturer of ferro-tungsten, providing for 600 kilowatts of use and producing a yearly gross income of about $25,000.

Connecticut

BRIDGEPORT.—The American Brass Company plans a new factory and foundry building 320 by 98 feet. It will cost $158,000.

Illinois

CHICAGO.—The Annicot Smelting Plant has been purchased by Haris Brothers Company for machinery manufacturing, for $100,000. The property consists of 8 acres of land at Chicago Heights.

CHICAGO.—James A. Brady Foundry Company has purchased a site for a group of buildings which will cost $300,000. The site is located at the corner of Westen Avenue and Forty-fifth Street.

Iowa

DAVENPORT.—It is reported that the Dewey Portland Cement Company, now operating a cement plant at Dewey, Okla., is to build a 1,250,000 barrel plant at Buffalo, Ia., ten miles southwest of Davenport.

MASON CITY.—Plant No. 2 of the American Brick and Tile Company, which was destroyed by fire in January, is now being rebuilt.

MASON CITY.—The Northwestern States Portland Cement Company is installing in its power house the Combustion Engineering Corporation's Type "E" Stoker with forced draft system.

Maine

LINCOLN.—The Eastern Manufacturing Company will build a coal discharging plant at its Lincoln Pulp Mill which will cost $36,000. It will have a capacity of 200 tons of coal per hour.

Maryland

BALTIMORE.—The Inter-Ocean Oil Company will spend $2,000,000 in erecting one of the largest oil plants in the section at East Brooklyn. The United States Asphalt Refining Company, a subsidiary concern, purchased 105 acres of land some time ago and the plant will be built on a part of this land. The land is north of the present plant of the asphalt company, which is located near the water front. The construction work was started some time ago and will be speeded up from now on. The company will make gasoline and various oil products. Fuel oil will also be made. The company operates a paint plant which manufactures asphalt paint for water proofing and roofing.

Massachusetts

MALDEN.—The Eastern Smelting and Refining Company of Somerville has purchased 14 acres of marsh land and will erect a building for smelting and refining of copper and tin. The plant will employ about 200 men.

SALEM.—The Rogers-Shear Company of Warren, Pa., is the concern which has leased in part the Forest River lead mills plant. The business to be carried on is said to be the manufacture of dry colors.

Minnesota

AKELY.—The Northern Wood Products Company planned to build a factory at Akely some time this summer. The company will manufacture turpentine, tar, rosin, sheep dip, oil and other various products from the stumps received from the farmers.

Missouri

JOPLIN.—The American Metal Company, Ltd., of New York, which has been using from 8000 to 12,000 tons of zinc concentrates yearly from the Joplin mining district, entered the field as producer of ore through a deal closed recently by Victor Rakowsky, under whose direction the Picher and the Butte and Superior ore tracts in Oklahoma were developed.

First leases on 14,000 acres of land passed from Rakowsky to the American company in the deal, which probably involves the largest acreage ever obtained in the United States by any major zinc corporation for the development of zinc tonnage.

The American Metal Company is the largest zinc smelting corporation in America, with a smelting capacity in excess of 50,000 retorts in plants at Bartlesville and Blackwell, Okla., and Langeloth, Pa., near Pittsburgh. The company has smelted a major part of the product of the Butte and Superior Mining Company of Butte, Mont., whose mines, the largest in the world, were developed under Rakowsky's direction in 1903-1904.

The concentrates from the 14,000 acres are expected to largely meet the company's demand, but it is not expected to cease buying on the market.

ST. LOUIS.—The Provident Chemical Works is completing a group of three new buildings on Idaho Avenue which will cost when finished over $150,00. The buildings will be used for the manufacture of acid phosphates. C. E. Udell is president of the Company, C. J. Young is secretary. The company has been operating in St. Louis for a number of years.

New Jersey

BAYONNE.—The Marvelo Products Company, 1041 Avenue C, has been organized to manufacture chemical preparations. Daniel A. Loori and Louis Gates, Jr., are heads of the company.

NEWARK.—The Hanson & Van Winkle Company, 269 Oliver Street, manufacturer of chemicals, has filed plans for improvements and extensions in its foundry on Chestnut Street.

NEWARK.—The Hanovia Chemical Manufacturing Company will build a 1-story addition to its plant at 233 New Jersey Railroad Avenue.

NEWARK.—The Texas Oil Company has purchased a site for a new plant on the Newark Meadows for the manufacture of gasoline, etc. The plant will cost $250,000. The plant will use one of the modern cracking processes.

NEW BRUNSWICK.—The plant of the Weiler Manufacturing Company, manufacturer of explosive chemicals, has been acquired at public auction by John J. White, Inc., New York, for about $25,000. Randolph Perkins is operating the plant for the new owners.

RUTHERFORD.—The Burns Chemical Manufacturing Company of Brooklyn, N. Y., has purchased two acres of land along the line of the New Jersey and New York Railroad and will transfer its plant from Brooklyn to East Rutherford.

TRENTON.—The Mitchell-Bissell Company, Fourth Avenue and Twentieth Street, New York City, has leased a section of the Prospect Hill Pottery plant and will establish a factory for the manufacture of porcelain specialties used in silk making. Machinery is now being installed.

New York

ELMIRA.—The Elmira Foundry Company has purchased considerable land adjoining its present foundry and plans to make large additions.

North Carolina

ASHEVILLE.—It is believed that the plant of the United States Leather Company which was recently destroyed by fire will be rebuilt.

RALEIGH.—The North Carolina Farmers' Co-operative Fertilizer Union will build a large fertilizer plant in Raleigh. The authorized capital stock is $500,000.

Ohio

CINCINNATI.—The Newport Rolling Mill plans an addition to its plant. It will cost $50,000.

CLEVELAND.—The Stevens Grease and Oil Company of Cleveland will install new equipment at its plant here and also construct a new plant in Kansas City. The company recently increased its capital stock from $100,000 to $150,000.

MARIETTA.—The Northwestern Chemical Company is making improvements in its plant which include a new office building and a one-story warehouse, together with other additions.

MARTIN'S FERRY.—The Wheeling Steel and Iron Company is planning to build a blast furnace, a steel plant and a plate and skelp mill at Yorkville, two miles north of this place. The estimated cost of the plant is $5,000,000. The company already has five big plants in this vicinity. Electric power is to be used for driving the new mills.

WARREN.—A new steel company plans a new sheet mill of six units on a 100-acre tract near Warren. Mr. Edward F. Clark of the Trumbull Steel Company is one of the organizers of the new company. The capitalization will be $600,000.

Pennsylvania

CHESTER.—The Crown Smelting Company is building a 2-story addition to its plant on Concord Avenue.

EASTON.—The Thomas Iron Company is planning for the early operation of its Lockridge furnaces, Hokendauqua. The company has announced that the contemplated sale of its property to W. H. Bilyeu, Philadelphia, for a consideration of about $3,500,000, has been abandoned.

KANE.—The glass plants in this part of the state have been shut down for several weeks due to fuel and raw material shortage. They have recently resumed operations.

PHILADELPHIA.—The American Metal Works plans an extensive addition to its plant to include a four-story factory building and a one-story metal plating shop.

PHILADELPHIA.—Edward G. Budd Manufacturing Company, manufacturer of automobile parts, has awarded a contract for the erection of a 1-story machine shop addition, 123 x 175 ft., to cost $55,000.

PHILADELPHIA.—F. Weber & Company, 1125 Chestnut Street, manufacturer of paper goods, will build a new 6-story brick and concrete plant, about 40 x 150 ft., at Twelfth and Buttonwood Streets.

PHILADELPHIA.—The Gill Glass Company has had plans prepared for five 1 and 3-story additions to its plant at Amber and Venango Streets, to form a new manufacturing works.

PHILADELPHIA.—The Alan Wood Iron and Steel Company has increased the appropriation for extensions and improvements at its Ivy Rock plant from $1,000,000 to $3,000,000. The erection of a new plate mill is planned. A new open-hearth furnace, making the eleventh at the plant, has been started and plans are under way to inaugurate the operation of a further addition, forming the twelfth unit now in course of construction, by the close of April.

POTTSTOWN.—The Eastern Steel Company is making rapid progress in the erection of its new No. 2 Stack, and expects to place the plant in service within a month. It will be one of the largest furnaces in this district.

Tennessee

MASCOT.—The American Zinc Company will build an $80,000 zinc mill at this place.

NASHVILLE.—The Tennessee Chemical Company will erect a plant to manufacture sulphuric acid at this place.

SWEETWATER.—Work on rebuilding the Durex Chemical Company is proceeding rapidly, and it is expected to have the buildings done in a short time.

Utah

SALT LAKE CITY.—The American Smelting Refining Company will spend over $1,000,000 in improvements to the Garfield Smelter, which will make it one of the largest in the world. Work has been delayed on account of the difficulties in getting quick deliveries of material. The increase in production of copper ore at the Bingham mines of the Utah Copper Company and the heavy demand for metals is responsible for the increase. The present capacity is 20,000 tons of ore per day. With the addition to be made the plant will have a capacity of 30,000 tons of ore per day.

Canada

HAMILTON, ONT.—The National Abrasive Company of Boston and Amesbury, Mass., manufacturers of carbolon, an abrasive material for grinding and polishing purposes, have decided to locate in Hamilton and have bought an acre and a half of land on Biggar Avenue, near Lottridge Street. They will start erecting a factory immediately and expect to start operations in 90 days, and at the start will employ about 75 men. The equipment and material are being ordered through the Ritchey Supply Company of Toronto, who are the selling agents for this company in Canada.

Nathan C. Harrison, treasurer of the Harrison Supply Company, through which concern they market their products in the United States, is also president of the National Abrasive Company, and he has connected with him J. T. Johnston, who is looking after the erecting and equipping of the Hamilton factory.

West Virginia

DURBIN.—The Pocahontas Tanning Company is rebuilding its plant which was destroyed last month at a loss of $500,000.

WHEELING.—The large plant of the United Zinc Smelting Corporation, just south of the city, is rapidly nearing completion. Included in the plant is a large acid plant.

WINIFRED JUNCTION.—The Ohio Cities Gas Company plan the erection of a chemical plant at this place. The plant will manufacture bromine, calcium and magnesium chlorides and common salt.

Wisconsin

WATERTOWN.—The Electric Steel Casting Company of Milwaukee is contemplating to establish a plant in this city if satisfactory arrangements can be made. It is capitalized at $300,000.

Manufacturers' Notes

AMERICAN CYANAMID CO. TAKES NEW OFFICES.—The American Cyanamid Co. announces the removal of its general offices on March 20 to 511 Fifth Avenue, New York City, where it occupies the tenth and eleventh floors of the Postal Life Building, at the corner of Fifth Avenue and 43d Street.

FREDERIC DE P. HONE & CO., engineers, have removed their office to 13-21 Park Row, New York.

LEAD FOR THE GOVERNMENT.—The Council of National Defense has estimated that from 15,000 to 50,000 tons of lead will be needed by the Government for the Army and Navy during the balance of this year. The price to be paid for this will be decided upon by a committee of producers acting in co-operation with Government authorities.

GENERAL CERAMICS COMPANY EXPANSION.—The General Ceramics Company, formerly the German-American Stoneware Works, was originally organized for the sole purpose of manufacturing high-grade chemical stoneware in accordance with the best German and American practice. During the past few years it has, by the purchase and development of existing plants and the erection of new factories, increased its lines of manufacture to include a large variety of ceramic products, and intends to add to this such other ceramic products as circumstances may dictate.

SOTHMAN CORPORATION FORMED.—The frequent wishes of many of the clients of the consulting firm of P. W. Sothman & Co. that it should extend its scope to include actual construction has led to the formation of The Sothman Corporation, with main offices at 40 Exchange Place, New York.

The officers and staff of P. W. Sothman & Co. have had long practical experience in the building of hydraulic, steam and gas-generating plants, and of all manner of transmission lines, both high and low tension, overhead, underground and submarine, as well as in the construction of distribution systems, waterworks, cooling plants, etc.

The corporation is also prepared to negotiate the sale of plants, processes and devices, subject to its examination, and report on the same.

GLASS MEN MEET AT PITTSBURGH.—The annual spring conference of the National Association of Window Glass Manfacturers was held at the Fort Pitt Hotel in Pittsburgh, April 11. The morning session was devoted to a discussion of gas shortage and its effect on manufacturers of glass during the winter months. Several manufacturers wished an extension of the working scale to allow them to recoup losses suffered because of the shortage during February and March. This proposition was defeated. It was voted to increase the wages of all employees at hand factories 10 per cent.

Adequate means of combating the shortage of raw materials, including sand and soda ash, were also considered. According to members of the association in attendance at the meeting, the pronounced shortage of freight cars during the last year has caused serious interruption of business.

The afternoon session was devoted to the discussion of working conditions, which were declared favorable. J. M. Neenan, president of the Window Glass Workers' Union, addressed the meeting. The annual summer convention of the organization will be held at New York City July 24, 25 and 26.

GIBB INSTRUMENT COMPANY MOVES.—The Gibb Instrument Company of Pittsburgh has moved its offices and laboratories to 5716 Euclid Avenue, Cleveland, Ohio.

THE BRAEMER AIR CONDITIONING CORPORATION was organized to take over on Jan. 1, 1917, what was previously the Air Conditioning Department of Warren Webster & Co. of Camden, N. J.

The company has secured the good will, patent rights, all engineering data, tests, records and patterns for the manufacture and sale of the Webster air conditioning apparatus for air washing, dust removal, humidifying, etc., and the Braemer system of humidity and temperature control. The main office of the company is in the Lafayette Building, Philadelphia, Pa.

RUSSIAN PLATINUM INDUSTRY.—The production of platinum in Russia and the prices of 83 per cent platinum prevailing for the last five years are as follows, according to the explanatory memorandum of the Russian Minister of Finance to the Budget for 1917. Data sent to the Bureau of Foreign and Domestic Commerce by the commercial attaché:

	—Production.—		—Average price.—	
Years.	Poods.	Troy ounces.	Rubles, per pood.	Dollars per troy ounce.
1911.....	352	185,337	36,365	$69
1912.....	337	177,439	37,939	72
1913.....	299	157,431	36,883	70
1914.....	298	156,904	36,864	70
1915.....	206	108,465	67,305	130

PULVERIZED FUEL FOR CEMENT KILNS.—The Locomotive Pulverized Fuel Co., 30 Church Street, New York, makers of apparatus for burning pulverized fuel, states that the cement business in this country now represents an investment of about $250,000,000 in over 150 plants which average a production of about 100,000,000 barrels of cement a year. The production of this cement involves the use of over 6,000,000 tons of pulverized fuel in the kilns, and about the same quantity of coal for the operation of the power plants. The company claims that the generally used method for burning the pulverized fuel in the kilns is quite ineffective and uneconomical, and that the opportunity for reducing the total cost of fuel per barrel of cement produced is enormous.

EXPORTS FROM SHANGHAI TO THE UNITED STATES

Articles	1915 Quantity	1915 Value	1916 Quantity	1916 Value
Antimony:				
Crude, pounds	1,268,000	$146,220	1,869,456	$302,290
Regulus, pounds	3,376,000	773,737	1,883,400	457,027
Chemicals, Drugs, Dyes and Medicines:				
Albumen, pounds	1,514,645	629,083	1,886,377	1,003,214
Aniline dyes, pounds	1,301,312	1,865,723	201,771	540,227
Camphor, pounds	22,420	6,419	67,792	25,698
Indigo paste, pounds	2,441,821	2,482,129	406,466	546,471
Soda, benzoate of, pounds	4,708	7,607	15,941	68,069
Turmeric, pounds	131,666	3,914	1,156,386	56,080
Cold, Chinese bars	.....	5,634,884	.....	114,122
Iron, pig, tons	7,580	100,106	8,658	152,472
Oils, Vegetable:				
Bean, pounds	290,880	15,233	319,018	27,977
Cottonseed, pounds	9,151,100	430,938	10,831,673	680,663
Peanut, gallons	25,099	13,441	183,522	111,401
Wood, gallons	83,059	39,919	26,893	18,421
Silver, Mexican dollars	.....	167,010	.....	262,291
Tallow, vegetable, pounds	112,005	8,498	1,380,063	102,012
Zinc ore, tons	1,241	37,474	101	7,725

OUR TRADE WITH PRINCIPAL CHINESE PORTS IN 1916.—In 1916, according to Commerce Reports, American purchases of cottonseed oil shipped from Shanghai increased by $249,725 due to the high price in the United States. Peanut oil, which showed a value of only $491 in 1914 and $13,441 in 1915, advanced to $111,401 in 1916. There are only two items of export to the United States that show large decreases. Aniline dyes and indigo paste decreased by over 3,000,000 lb., valued at over $3,000,000. The dye trade was very speculative during the year, following on the previous years' enormous profits, and the natives have invested considerable amounts in dyes, paying high prices, expecting a continued demand from Europe and the United States, which, however, did not materialize.

The following items were exported from Hongkong to the United States:

Articles	1915	1916
Antimony	$49,301	$104,980
Chemicals	107,215	166,788
Explosives, Fireworks	20,006	46,321
Hides	.....	64,612
Leathers	23,796	54,872
Oil:		
Peanut	90,980	91,035
Sugar	28,697	47,298
Tin	983,884	1,261,737

In regard to imports at Hongkong, the Consul General has the following to say:

"In the drug and chemical trade American goods have been introduced in some lines, which will mean a permanent trade independent of all war conditions, for the Hongkong importers have found that in many of the standard products American prices and qualities are far more attractive than European prices and commodities even before the war. In the line of chemicals and drugs there is every reason to expect a marked change in the course of trade from now on and independently of war conditions.

"Imports of American condensed milk, a great trade in China and one of increasing importance, show a considerable gain.

"Of the great mass of miscellaneous imports, novelties and sundries, and such imports as leather goods, woolens, blankets, rugs, carpets, toilet articles and toilet supplies, paper, stationery, etc., Japan has secured much of the cheaper trade formerly held by Germany, but the United States is furnishing most of the better class of goods in all such lines. In a general way Japan has maintained its lead secured in this general trade, but American exports of such goods have more than held their own, and the trade is largely American, and much of it is on a permanent basis."

In the Canton district a mining director was appointed for the Provinces of Kwangtung and Kwangsi, and instructed to find means for the development of the mineral wealth of these two provinces, which is known to be considerable. The newly appointed mining director left Canton in September, 1916, and has made his headquarters at Kiungchow, in the island of Hainan, the mineral resources of which are believed to be considerable, but so far little or nothing has been done to develop them. The chief development in mining during 1916 was in the mining, smelting and refining of antimony ore, which is produced in many district in the Provinces of Kwangtung, Kwangsi and Yunnan. Owing to the demand for this article caused by the war in Europe, a great stimulus has been given to its mining and export, and dealers and miners have realized large profits. There are at present several antimony smelters established in Canton and Hongkong for the refining of the ore. It is stated that steps are being taken to encourage the establishment of smelting works in Kwangsi Province, and that the Chinese are opposed to the trade in antimony being handled by foreign firms.

From statistics at hand it is believed that the export of tin from the mines at Kochiu, Yunnan, will show a considerable falling off as compared wih 1915.

From Canton we received 2063 lb. of dyes (unclassified) in 1916, valued at $13,577, as compared with none in 1915. This is the only article of direct interest in our field which came from this port in 1916.

REPORT OF INDUSTRIAL COMMISSION TO FRANCE.—A book that should be of interest and value to American manufacturers is the report of the American industrial commission to France. The report, entitled "Franco-American Trade," has been issued, according to *Commerce Reports*, in a 256-page volume, with numerous illustrations and industrial maps. The commission of fifteen members was organized by the American Manufacturers' Export Association to return the visit to this country of the French trade commission, and the commissioners were in France from September to October, 1916. The report deals with trade, the tariff and shipping; agriculture, mining and manufactures; transportation, syndicates, co-operative societies, chambers of commerce, and courts of commerce; labor and social welfare; and city planning. There are also chapters on the important hotel and resort industry of France, on general and technical education, on the devastated regions, on the society for the resumption of industrial activity in the invaded regions, on Belgian reconstruction, and on the Lyon Sample Fair. The book has an excellent bibliography, which includes the thirty-five monographs dealing with France issued by the Bureau of Foreign and Domestic Commerce. Copies of the report may be purchased through the American Manufacturers' Export Association, 160 Broadway, New York City.

INCREASED GRAPHITE PRODUCTION.—The production of flake graphite has increased steadily during the last three years, owing to the great demand for it for use in making crucibles. H. G. Ferguson, of the United States Geological Survey, estimates that the production of flake graphite for 1916 was about 11,500,000 lb., as compared with 7,074,370 lb. in 1915 and 5,220,539 lb. in 1914. Alabama furnished about 5,500,000 lb., and the remainder came from mines in California, Montana, New York and Pennsylvania. In all sixteen companies produced flake graphite. The imports of flake graphite, chiefly from Ceylon and Madagascar, far exceeded the domestic production. Owing chiefly to the immense demand for crucibles for use in making munitions, the beter grades of flake graphite now command more than double the prices at which they sold before the war. Most of the amorphous graphite used in this country is imported from Mexico and Chosen (Korea), but a total of 2562 tons was obtained from mines in Michigan, Nevada, North Carolina and Rhode Island. Amorphous graphite is not suitable for use in the manufacture of crucibles but can be used for making lubricants, pencils, paints and foundry facings. The price of amorphous graphite varies according to the grade of the product and has not been greatly increased by the war.

UNITED STATES EXPORTS OF COPPER.—The following table, prepared by the National Conduit & Cable Company, New York City, shows the countries to which our copper went last year and in 1915.

UNITED STATES EXPORTS OF COPPER
By Countries
In Tons of 2240 Lb.

Destination	1916	1915
United Kingdom	79,045	80,985
France	150,086	102,440
Germany	.....	.....
Holland	2,702	1,678
Belgium	.....	.....
Austria	.....	.....
Italy	51,099	44,705
Denmark	3,416	2,426
Norway and Sweden	10,683	19,958
Russia	26,220	20,456
China and Japan	71	119
Sundries	3,988	3,577
	327,310	276,344
Canada	20,372	9,908
Contents of sulphate of copper	2,171	1,200
Total	349,853	287,452

MANY USES FOR TURPENTINE AND ROSIN.—Although classed as "naval stores," turpentine and rosin are used today for a wide variety of purposes which have nothing whatsoever to do with shipping. More rosin, for example, is used in the manufacture of soap than in anything else, and its second most important use is in making paper suitable for printing and writing. The name "naval stores" as applied to these products is a reminder of the old days when tar and pitch, the first articles to be obtained from the pine trees, were more important commercially than turpentine and rosin. The former articles were used in the shipping industry for caulking seams and smearing ropes, and when turpentine and rosin, as well as tar and pitch, began to be obtained from the long-leaf pine and similar trees in the Southern States, the name "naval stores" was extended to these also.

The wide variety of uses to which turpentine and rosin are put today is realized by only a few persons. The leather and paper laboratory of the Bureau of Chemistry, U. S. Department of Agriculture, has prepared lists of uses of these two interesting materials. The uses of turpentine follow. The uses of rosin will be given in our next issue.

USES OF TURPENTINE

Volatile thinner for paints, varnishes and wood fillers.
To accelerate oxidation of drying oils (as an ozonizer).
Solvent for waxes in shoe and leather polishes, floor polishes and furniture polishes.
Solvent for gums in lacquers and varnishes.
Ingredient of waterproof cements for leather, rubber, glass, metals, etc.
Solvent for waterproofing compositions.
Cleaner for removing paints and oils from fabrics.
Pharmaceutical purposes, including:
Disinfectants.
Liniments.
Medicated soaps.
Internal remedies.
Ointments.
Raw material for producing synthetic camphor and indirectly,
Celluloid.
Explosives.
Fire-works.
Medicines.
Raw material for producing terpineol and eucalyptol.
Raw material for producing terpinhydrate used in medicines.
Raw material for producing isoprene used in making synthetic rubber.
In the manufacture of sealing wax.
In glazing putty.
Ingredient of some printing inks.
In color-printing processes in lithography.
Lubricant in grinding and drilling glass.
As a moth repellant and in moth exterminators.
Constituent of insecticides.
For cleaning firearms (alone or in combination with other materials).
In laundry glosses.
In washing preparations.
In rubber substitutes.
In wood stains.
In stove polishes.
In modeling waxes and grafting waxes.
In belting greases.
In drawing crayons.
In the manufacture of patent leathers.
As a substitute for pine oil in flotation concentration of ores.
Solvent for rubber, caoutchouc and similar substances.
Used to prevent "bleeding" in the manufacture of cotton and woolen print goods.
Laboratory reagent as substitute for more expensive organic solvents.
Oxygen carrier in refining petroleum illuminating oils.
Colored turpentine, reagent for wood and cork in biological technic.

Manufacturers' Catalogs

PYROELECTRIC INSTRUMENT CO., 148 East State Street, Trenton, N. J., has issued an attractive catalog on the Northrup pyrovolter describing their different instruments and giving a price list.

ELECTRIC MACHINERY COMPANY, Minneapolis, Minn., has issued an attractive book on "Bank Your Water-Power," which is Bulletin No. 175. It describes a type of installation for water powers of low head, viz., a vertical alternator direct connected to a vertical waterwheel.

DOEHLER DIE-CASTING CO., Brooklyn, N. Y., has issued an attractive book entitled "Creating an Industry." It gives the history of the company and its products and technical historical data.

THE BROWN HOISTING MACHINERY CO., Cleveland, Ohio, has issued catalog P, describing the Brownhoist overhead hand traveling cranes.

LOCOMOTIVE PULVERIZED FUEL COMPANY, 30 Church Street, New York City, has issued Bulletin 3, dated March, 1917, describing L. P. F. combination conveyor, feeder and commingler adapted to cement kilns.

TRAYLOR ENGINEERING & MANUFACTURING COMPANY, Allentown, Pa., has issued Bulletin R-I describing their crushing rolls, jaw crushers and gyratory crushers.

CLARK DUST COLLECTING CO., Fisher Bldg., Chicago, Ill., has issued a booklet on the American automatic dust filter, describing their 1917 models.

Other New Publications

THE GEOLOGIC FORMATIONS OF CALIFORNIA. The State Mining Bureau has just issued Bulletin No. 72, with the above title. It was written by Prof. James Perrin Smith of Stanford University, and contains a complete bibliography and résumé of all of our present knowledge relative to the geological formations occurring in California. It also contains much previously unpublished data, and covers 41 pages, and six tables showing geologic columns. The bulletin is published in conjunction with the Geologic Map of California, recently issued, and is sold separately, price 25 cents, post prepaid. Address State Mining Bureau, Ferry Bldg., San Francisco, or State Mining Bureau, 520 Union League Bldg., Los Angeles.